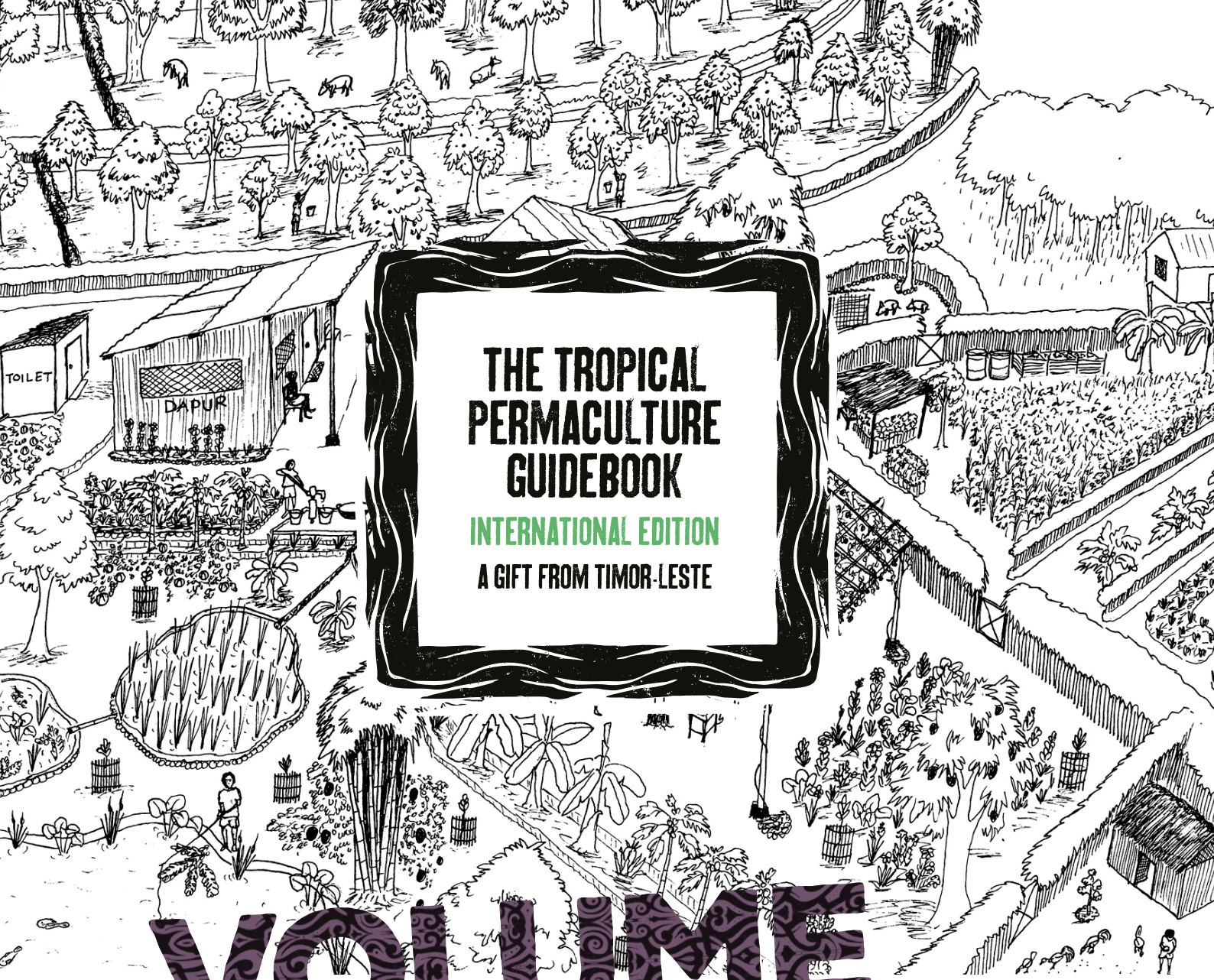

THE TROPICAL PERMACULTURE GUIDEBOOK

INTERNATIONAL EDITION

A GIFT FROM TIMOR-LESTE

VOLUME TWO

HOUSE AND GARDEN

Vol 2 of 3 | ISBN: 978-0-6481669-7-9

The Tropical Permaculture Guidebook – International Edition.
A Gift from Timor-Leste.

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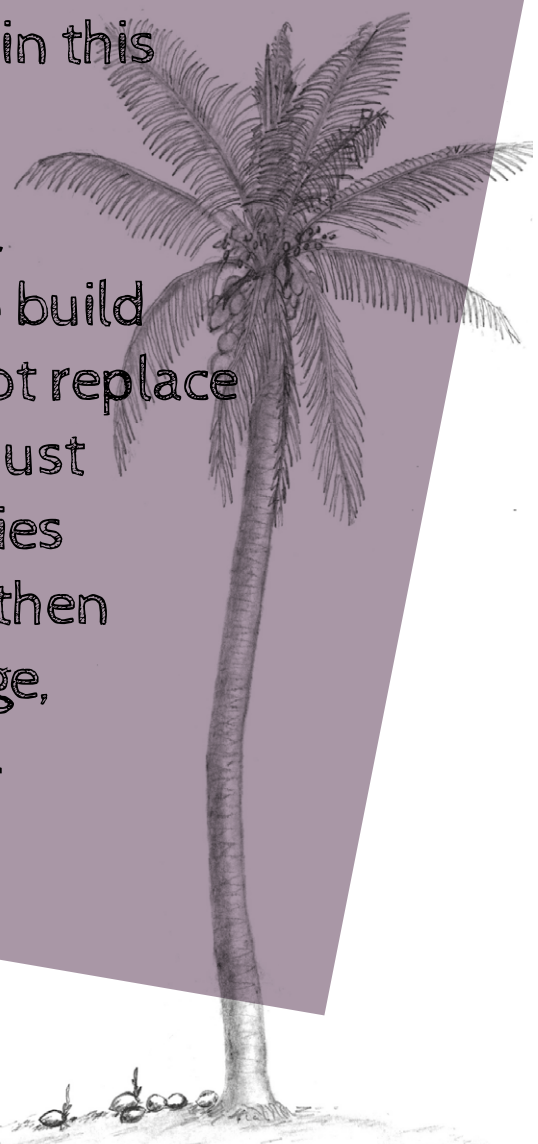
A gift from Timor-Leste to the tropical world.

This guidebook is based on an original book written specifically for Timor-Leste by Permatil. The first edition was written with help and technical assistance from many Timorese and people from other countries living and working in Timor-Leste. The wealth of knowledge and incredible illustrations by Timorese artists from the original version is incorporated and expanded upon in this new edition.

It is a guidebook for all the tropical regions of the world. We want it to build on traditional knowledge bases, not replace them. The guidebook's goal is not just to introduce permaculture strategies and techniques, but also to strengthen and augment traditional knowledge, and complement cultural practice.



Foreword

Rosemary Morrow

Timor-Leste, where I taught and worked with some Permatil staff who are, by the way, extremely gifted designers and teachers, and the Fair Trade Coffee school, demonstrates most of the climates of the tropics. It is important for this book to be relevant to the worldwide tropics, and in Timor-Leste most of the sub-climates of the tropics exist in one small half-island.

As David Holmgren says, small islands can give rise to big projects and ideas. This book is one of those.

Timor-Leste has hot, wet tropics, monsoon tropics, elevated tropics, deltas and dry tropics - globally these are climates where farmers grow much of the world's food and most of their own. The world's tropics are rich and varied. And so is Timor Leste.

From Uganda to Peru these lands are seriously degraded and are worsening at an increasing rate simultaneously polluting rivers and wells. Productivity is decreasing. The threat of another 'green revolution' hangs over their heads and with that further soil impoverishment and pollution. They can also be victims of agricultural companies wanting to push herbicides and fertilisers.

Farmers are often deprived of the knowledge they require to reverse the destruction. They work very hard. They work as they always have because, at least, it gives them food and sometimes cash for essentials. Most of the world's poor farmers lack knowledge to change their lives. There is injustice in being deprived of useful relevant knowledge and skills. This book goes someway to remedying that.

Literate populations find it hard to imagine being taught valuable information yet having no reference book in their own language. Consolidation and verification of learning the written word in their own language is inexpressibly important for all people. One problem in permaculture is often the lack of a text even though the teachers are skilled and ethical. So the first edition of this book was written to allow farmers and gardeners to access permaculture knowledge in their own language.

The original *Permaculture Guidebook from Timor-Leste* came out in three languages and has been translated into others. I know chapters have been translated into Lugandan, the major language of Uganda. It has been downloaded and copied many times. I'm not sure if anyone knows how many, nor its impact.

This updated international edition, the *Tropical Permaculture Guidebook*, has been prepared based on the original guidebook's welcome from farmers, permaculturists, government agencies, NGOs and others working in the tropics. The first edition was a carefully written, edited, formatted and verified by the users. This second edition shows the same painstaking care to get it right. However it goes further.

Where there are abstract concepts such as 'water harvesting' the text or drawings add concrete examples. This not only appeals to unschooled farmers and gardeners, it also works for tactile learners. It includes 'smart ideas' and a staggering variety of techniques for all types of landforms.

It is far from being a manual, simply for people with little or no schooling, it will appeal to all 'growers' in many landscapes looking for new strategies and techniques with proven success. I recognised in this edition techniques and landscapes that will work in Lesotho or Afghanistan. And some made me want to head out to my garden and try them. I know my neighbours would like to as well.

The detail in the chapters is greater than in most permaculture books presently available across the world. Many chapters stand strongly alone. Chapter 10 on Family Gardens is almost a book in itself. Yet, links are made to other relevant chapters without diminishing the content. This is a strength where some countries consist of mainly small farmers, and others require the depth of subsequent chapters for full implementation.

The authors and artists know their farmers. The book is about 50% drawings. The text is clear and there is no jargon - that enemy of comprehension. This edition addresses a major omission from first edition as it specifically includes design.

The book is considerably revised through comments and assistance from NGO staff using the first edition; people with special skills in learning, and importantly, from farmers themselves. The layout is generous and the contents work with the text.

Those of us who work with people who are illiterate, or semi-literate know that the farmers may not read well, however they are perfectly able to represent the design in their heads and in ways that are clear and unambiguous. Not being able to read or write is no barrier to understanding illustrations.

Some farmers require assistance with reading books especially if their school years were spent reading photocopied papers. I know books like this also serve as reading materials for a family and I can see whole communities being 'schooled' in permaculture when the book appears.

It is no easy thing to get a book 'right'. It must be valuable enough to be consulted several times; its graphics must relate to the text; its text must put difficult concepts clearly; it needs to be good to handle; information needs to be relevant, retrievable and correct. This is a big work.

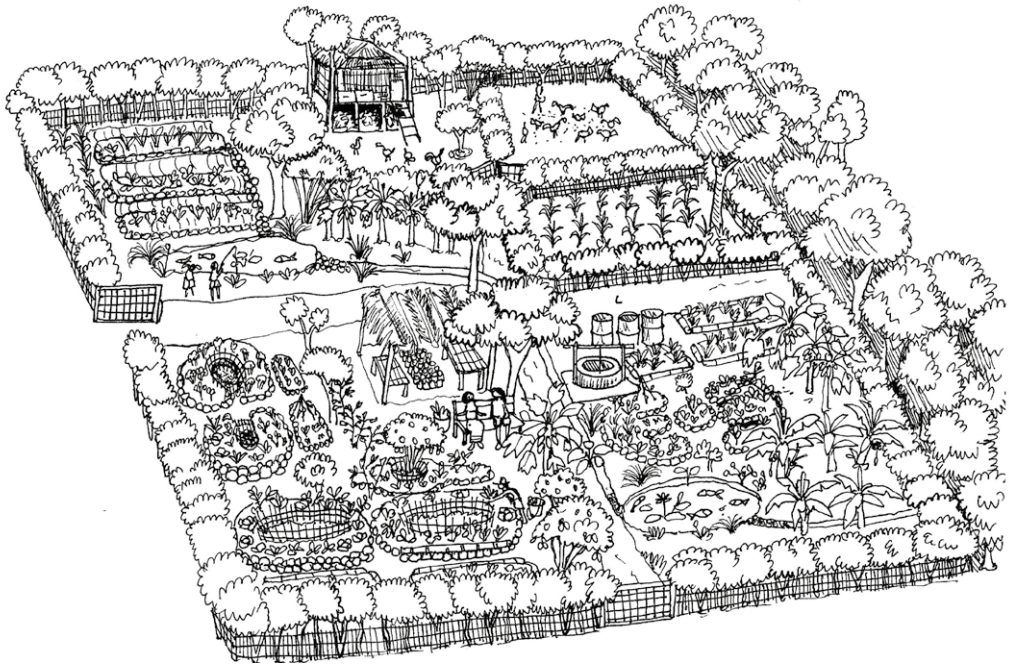
From very wet, to very dry, from flat to hilly, the book has encompassed a huge area and numbers of farmers and gardeners.

To take the words of co-author Lachlan McKenzie, "a strength of this book, following one of Permatil's core ethos, is that it provides strategies and techniques that can be taken and used by all farmers and guidebook users, no matter their circumstance, status or wealth."

This is a big, big achievement

Thank you Timor-Leste for the gift.

November 2016



Aims of the guidebook

Our goal is to help families and communities become more resilient, sustainable and productive, not just to survive but to be able to reach their full potential and thrive.

The guidebook provides information to improve basic wealth for all people, not just material wealth, but wealth in the environment, the trees, the animals, vegetables and grains, and wealth in the people, and their knowledge, skills and connections with others. **Real wealth**!

We wrote and illustrated the guidebook for many different people to use:

- Farmers.
- Community groups and their members.
- Agriculture and university students.
- NGO and government workers.
- Permaculture trainers and practitioner.s
- Demonstration sites.
- Businesses and cooperatives.
- Schools and school students.
- Anyone wanting to become more resilient, more sustainable and regenerate their environment!

The guidebook is created to help develop new projects and for redesigning and improving existing projects, houses, farms, environments and communities.

It is written and illustrated so that people with low literacy levels can use it and people with little or no income can benefit from it.

It provides techniques and solutions at all levels — for individuals, families, communities, businesses and governments, both regional and national.

We also want the guidebook book to improve over time. So, use it, share it, learn from the results of your work, and let us know your ideas for improvements to the guidebook and we will spread your experience. As the guidebook is on the internet, we can update it every year, and your input can create a better guidebook in the future!

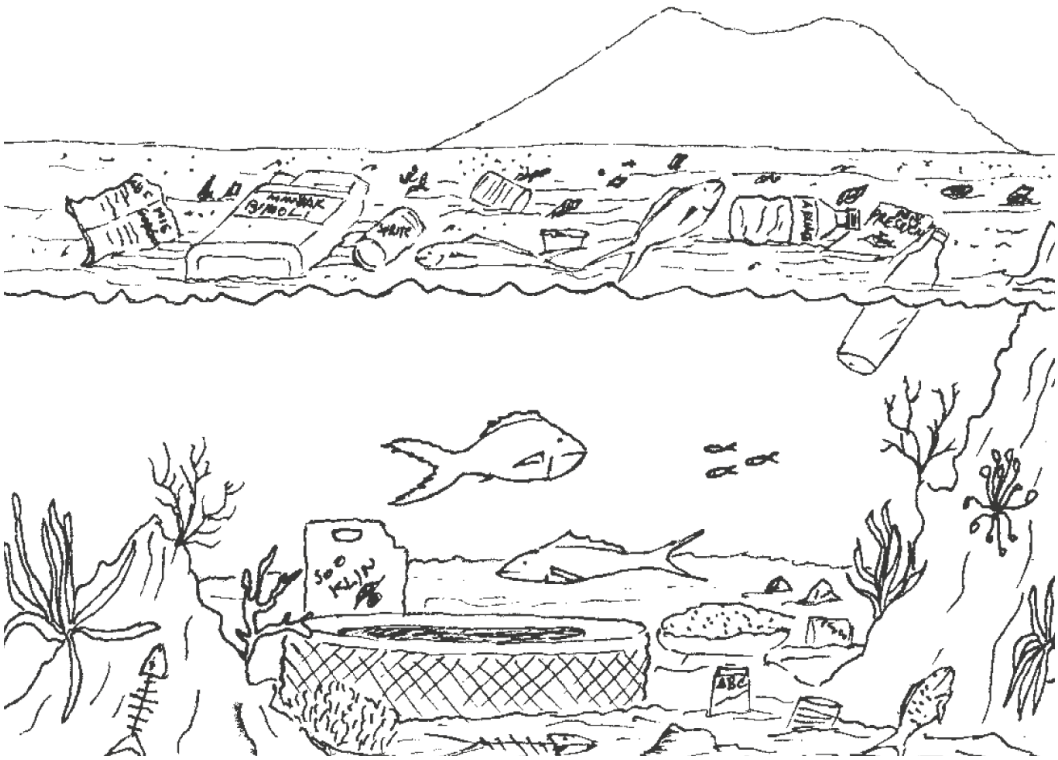
Our challenges

Globally we are facing many direct and serious challenges — to our environment, our productive land, our natural resources, and our social and community structures.

POLLUTION

Our land, water, oceans and air are in bad shape! All of them are being polluted by rubbish, chemicals, and the residues of our wasteful, destructive and careless ways of living.

Some of the problems can be repaired quickly — some will take much longer — but the solutions will have to come from big changes to how we live, how we produce and what we consume.



NATURAL RESOURCE DEPLETION

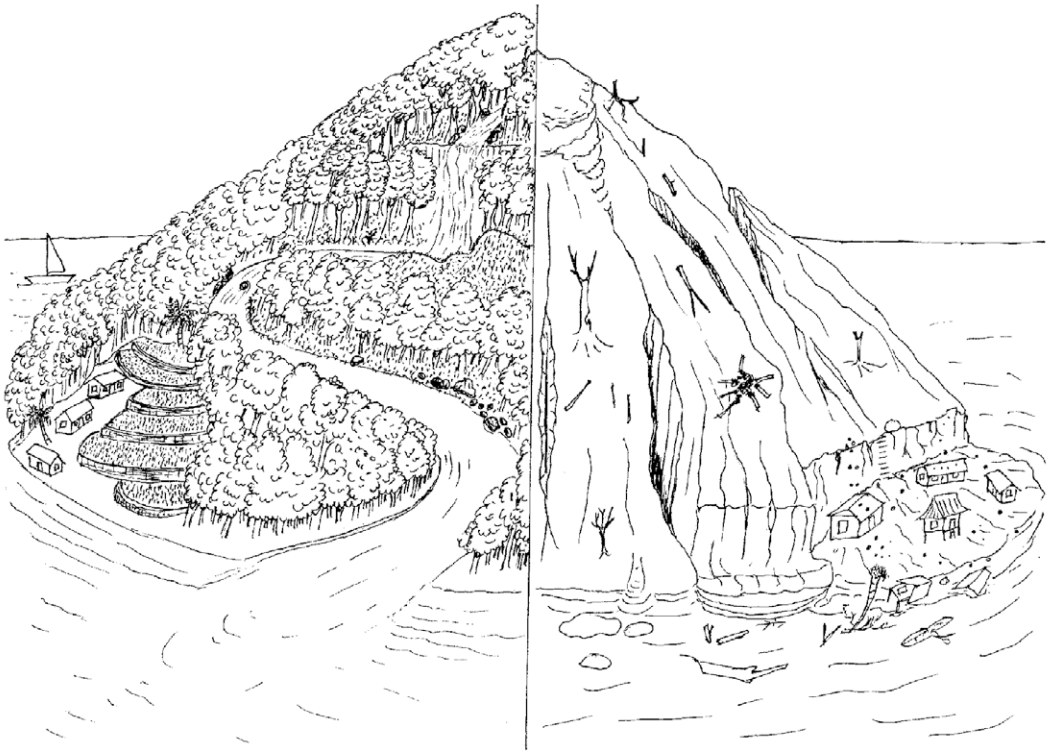
Water — underground supplies are quickly disappearing in many countries and, with bad land management and deforestation, the problem is getting worse. Rivers, lakes and oceans are more and more polluted, and rainfall is becoming more irregular as climate change takes effect.

Air — air pollution is increasing each year, causing sickness and sometimes even limiting our daily activities.

Soil — soil quality is decreasing worldwide, which increases water and resource use. Even worse is that each year there is an increase in the amount of land where the soil is so poor it cannot be used for agriculture.

Seeds — local varieties are quickly disappearing, and the range of seeds available for farmers is getting less and less. The problem leads to increased costs, higher pest problems, higher dependence and less genetic diversity.

Forests — deforestation continues and as it does, the amount of wood available to use decreases. Destruction of forests is a huge problem as not only do they affect rainfall, they are the world's lungs that turn the carbon produced through burning oil and gas into clean air. Forest depletion also negatively impacts on water supply, and causes erosion and landslides.

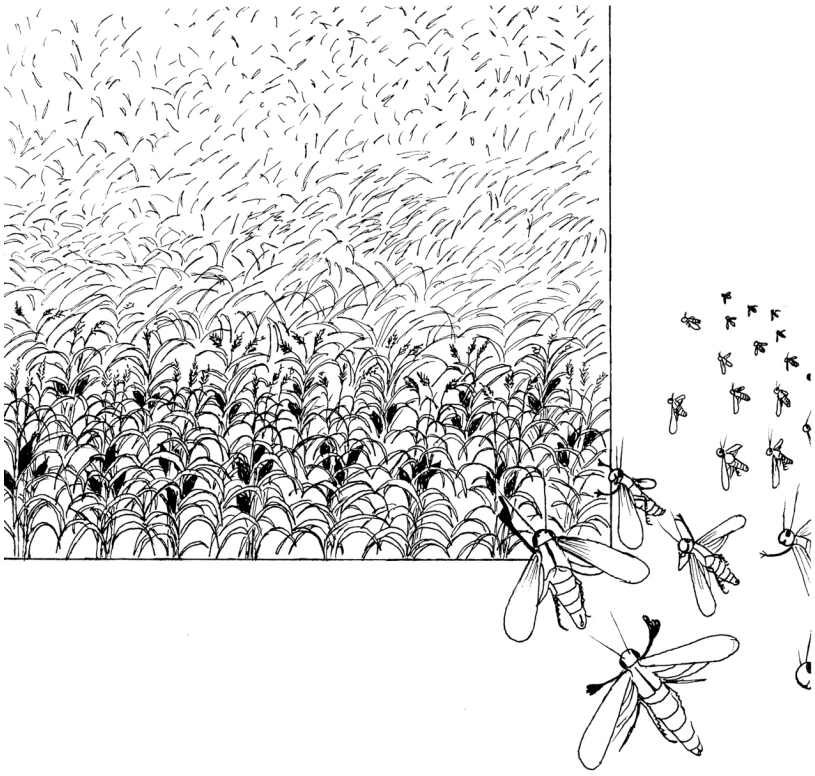


Plant, animal and insect diversity and numbers — The diversity of life on earth is decreasing rapidly creating imbalance for systems both in the natural environment and our food production. The systems become more fragile as a result and more vulnerable to climate change.

Oil, coal and natural gas — fossil fuels — these are finite resources and at the rate we are using them, we have reached the point where they are becoming more expensive, more environmentally destructive to extract and create pollution that we definitely cannot afford to create.

CLIMATE CHANGE

A lot of the technology and changes in our way of living that have helped to make life easier and better for many of us are also contributing to the huge global problem of climate change. It involves a long-term shift in world climate patterns, mainly the result of burning fossils fuels for our electricity, transport, food production, buildings and consumer goods.



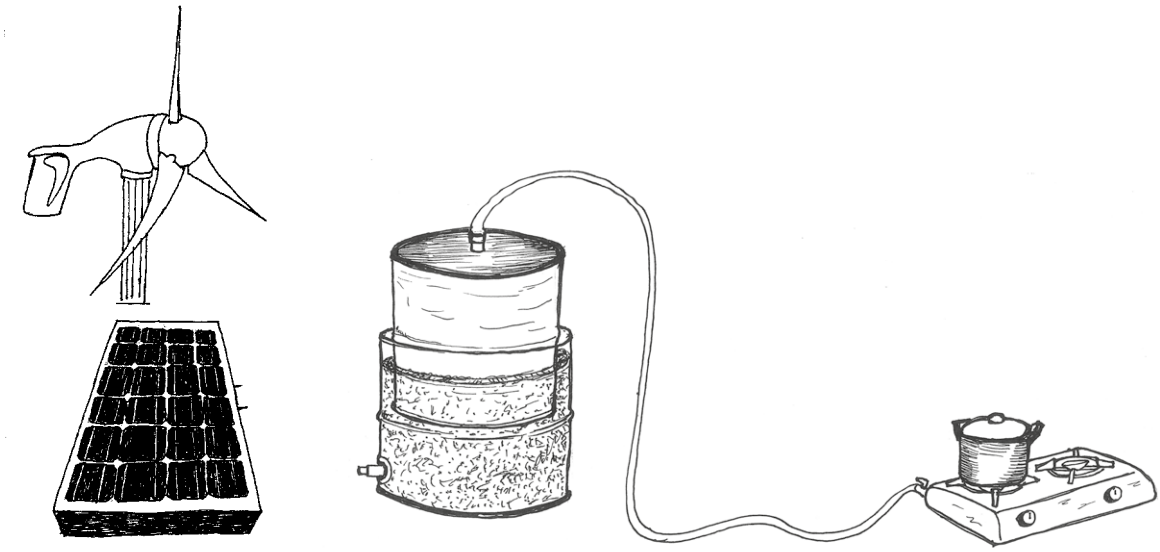
Industrial agriculture with large monoculture crops contributes to climate change

Too much carbon dioxide and methane gas — 'greenhouse' gasses — in the atmosphere is causing global warming, a rise in the earth's surface temperature. Global climate patterns are changing; rainfall is less reliable, storms are becoming more intense and temperatures more extreme. Ice and snow are slowly melting in many places as the temperature increases. The sea levels will rise a lot as the ice at the north and south poles continues to melt if we do not find solutions quickly. Low-lying areas, such as in Bangladesh, are already facing rises in sea level which have made some coastal land unlivable.

Climate change is becoming a big problem and will get much worse unless we make rapid and significant changes in how we live and how we manage the natural environment. Rather than destroy the earth's ecosystems, we must be stewards to protect it for all living things and pass on a healthy planet to our children, not controllers and consumers who leave nothing for future generations.

We are facing this global crisis because we have not understood or have ignored the consequences of our actions. Countries in the tropics have only contributed a small amount to the global problems, and yet the problems caused will affect every country. Every country must now act quickly to adopt lifestyles that will stop producing pollution, to contribute to regenerating the environment and to protect against the negative effects of climate change.

An imperative solution is to change to renewable energy sources, such as wind power, solar power, biogas, tidal and thermal energy, as quickly as possible. Changing how we produce our food and what we use and consume are also essential steps to take.



Climate change is occurring already but if we change quickly we can still minimise the impacts and consequences. If we do not act now climate change will get worse and make it very hard to live on the planet.

POPULATION

The world's population is rapidly rising, which increases pressure on resources, land for living and food production, and negatively affects the natural environment. Currently, the global population is almost 7.5 billion people!

We must:

- Find ways to reduce population growth in ways that are fair and just without imposing harsh regulations or creating hardship.
- Increase food production in a sustainable way that considers the impacts on the environment.
- Use and re-use all resources efficiently with an emphasis on quality, sustainability and recycling.
- Protect the natural environment and significantly limit our negative impacts.

URBANISATION

Urbanisation is when people move from rural to urban — cities and towns — areas. It is an enormous shift from a rural to an urban culture, especially with the changes in lifestyle that it involves. Over 50 per cent of the world's population now lives in urban areas, and this number continues to increase. Each of the world's top ten largest cities has at least 20 million people.

This creates specific pressures on the environment and natural resources that include:

- High levels of sewage and household waste.
- Much higher use of cement, steel and bitumen that increase urban temperatures.
- Bad air pollution.
- Polluted water, higher water use but less water catchment.
- High fuel use for cooking and for heating or cooling buildings.
- Houses and factories built on agricultural land.
- Resource depletion and environmental damage in the surrounding areas.

Solutions for sustainable urbanisation need to include larger-scale solutions for the challenges listed above.

GREED AND COMPETITION

The modern way of living and the values it incorporates have created many problems, such as:

- When our system values money and material wealth above all else, everything is consumed to get more money.
- Focusing on short-term material gain does not consider the long-term consequences on the environment or the planet.
- Consumerism and the consumption of goods that do not last or are quickly thrown away pollute the environment, which creates problems related to bad health, wasteful resource use and rubbish disposal.
- Many consumer goods are designed to last only a few years; they break and are replaced. The term for this is 'planned obsolescence' and it is to make more money for the businesses at the expense of the environment, causing resource depletion, pollution and climate change.
- Current financial systems still only react to problems rather than applying preventative measures so that problems do not arise at all — short-term solutions will not result in significant change.
- Big corporations and other powerful organisations/people control too many resources, are often not accountable for their actions and benefit only a few, which leads to inequality and the loss of rights and independence.

Our tools

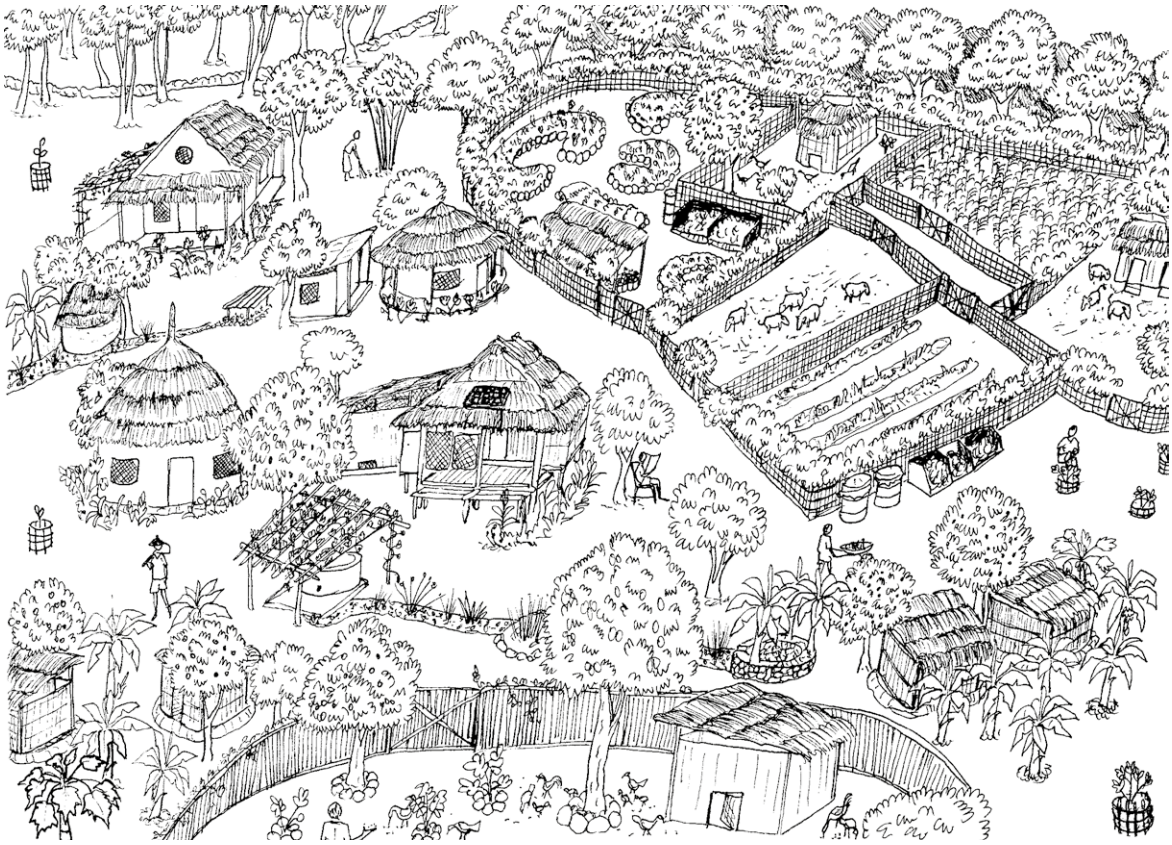
The task of overcoming these problems seems huge, but it is achievable. However, unified action must come from the majority rather than the minority, and there must be a change of mentality:

- How do we really want to live on this earth?
- How do we live well and live sustainably?
- How do we live as a part of the earth and its ecosystems, not separate as we are now?
- How do we regenerate the damaged ecosystems and the depleted soil and natural resources?
- How do we live a life that leaves the earth in a better state than when we were born?

PERMACULTURE

Permaculture involves designing integrated systems for families and communities to gain self-sufficiency and live in balance with the world around them. It is a series of strategies that provide a flexible framework for any situation, and the ability to choose and integrate the technical tools required to achieve resilience and sustainability. It facilitates the need to change our focus quickly from quantity to quality and helps to address the challenges that we face.

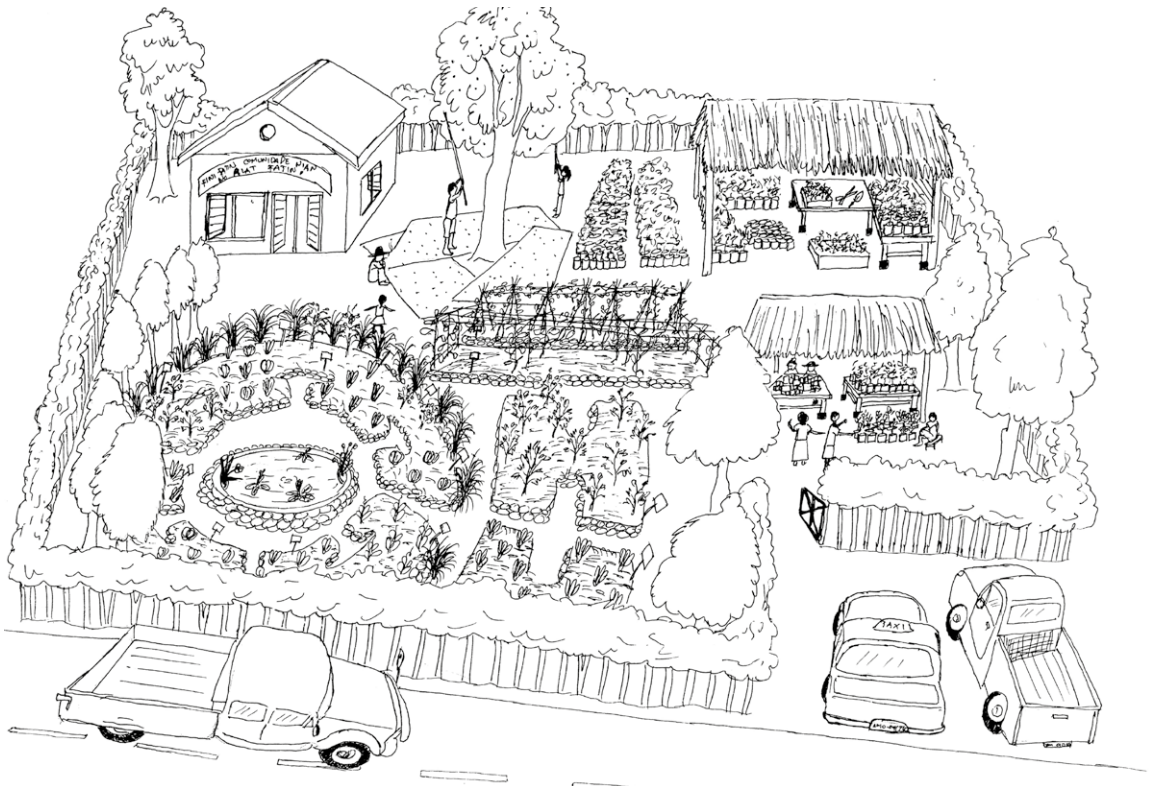
Permaculture is a regenerative process. This guidebook helps you to understand permaculture and how to apply it, especially in tropical regions. There is a lot more information available on specific topics from experts, training, books and the internet. Build on the knowledge the guidebook provides, bringing in other permaculture and sustainable living knowledge, and add your own experience too.



TRANSITION TOWNS

A concept born out of the permaculture movement, transition towns facilitate the conversion of communities from their current situation to being resilient, sustainable and regenerative. It encourages the growth from small actions to whole-town participation and provides the tools to achieve change in all facets of living — food production, transport, housing, energy and fuel, livelihoods (jobs), water, environment, economy, etc.

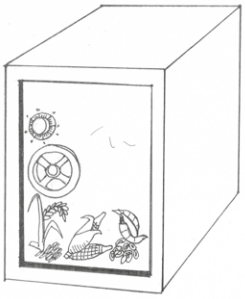
Read more in Urban and community permaculture (**Ch 4)**.



FOOD SOVEREIGNTY

70 per cent of the world's food is produced on less than five acres of land, and women produce 70 per cent of that food. This is the reality which should be encouraged, rather than following the method of large-scale monoculture crops.

Producing enough food for everyone relies on smarter, more intensive production from small landholdings using soil improving, organic, regenerative methods. Now more and more organisations, farmers, communities and governments understand that this method is the way to go. The industrial agriculture model has failed due to its reliance on outside resources, chemicals and mechanisation, the high costs and its vast scale, all of which drive people from the land, reduce livelihood opportunities, lead to soil and water degradation, and large-scale environmental destruction.



Food sovereignty embraces small-scale organic farming and food production, as well as other essential individual, social and environmental factors for producing food:

- Food is a basic human right.
- You can own the land that you farm.
- Protect the natural resources that produce the food (and ensure the people and local communities own them).
- Reorganise food trade to promote local consumption and food self-sufficiency.
- End the globalisation of hunger and reduce food wastage by protecting production, through regulation, from price speculation and corporate influence.
- Social peace — everyone has the right to be free from violence; food and food production must not be used as weapons or as means of control.
- Democratic voice — smallholder farmers must have direct input into formulating agricultural policies at all levels. Everyone has the right to honest, accurate information, and open and democratic decision-making.

Read the Urban and community permaculture chapter (**Ch 4**) for more details about food sovereignty and why it is important for all communities to achieve.

GLOBAL CHANGE

There are hundreds of thousands of organisations and millions of people all over the world working to create positive change. Their work is in many different areas:

- Environmental conservation.
- Reforestation and land protection.
- Campaigning against the pollution of air, water and land.
- Sustainable agriculture (organic, biodynamic, agro-ecological).
- Permaculture.
- Transition Towns.
- Renewable energy.
- Food sovereignty.
- Protecting native seeds, land and water.
- Indigenous empowerment and action.
- Ocean protection.
- Providing a voice for ethnic minorities, especially traditional landowners.
- Human rights and justice.
- Community resilience.
- Local food consumption .
- Animal welfare.
- Culture and art.

These organisations are community groups, cooperatives, networks, businesses, government, non-governmental organisations, large international organisations, advocacy groups, political parties and so on.

Every organisation is making a small but vital contribution to change; together there is massive change already occurring, and it is spreading. You are part of it!

EDUCATION

Learning is a key for change. This guidebook contributes in its own small way to the larger goal of education as a basic right. To address the challenges we face, we need to have knowledge of the strategies and techniques needed for broad change to occur.

How to use the guidebook

The *Tropical Permaculture Guidebook* is divided into three volumes. These volumes each have a theme to make it easier to find the information you need. Each volume contains:

- An introduction.
- A table of contents to help you find what you want to read.
- A glossary explaining technical words and terms.
- A reference section for where to find more information about the different topics.

Each volume contains six chapters that divide the information into clear, easy-to-follow sections. They are systematically organised to help you to plan, design and implement the techniques.

In each chapter there are many references to other elements and sections in the guidebook; for example, there are links to windbreaks, compost making, swales, integrated pest management, animal production and much more. This shows the connections between the different chapters and makes it easier to find the information you need.

You decide how to use the guidebook:

- Read several chapters together.
- Read them one-by-one as you need the information.
- Look up the specific strategies and techniques you want using the table of contents (TOC).

Volume One: Permaculture and People

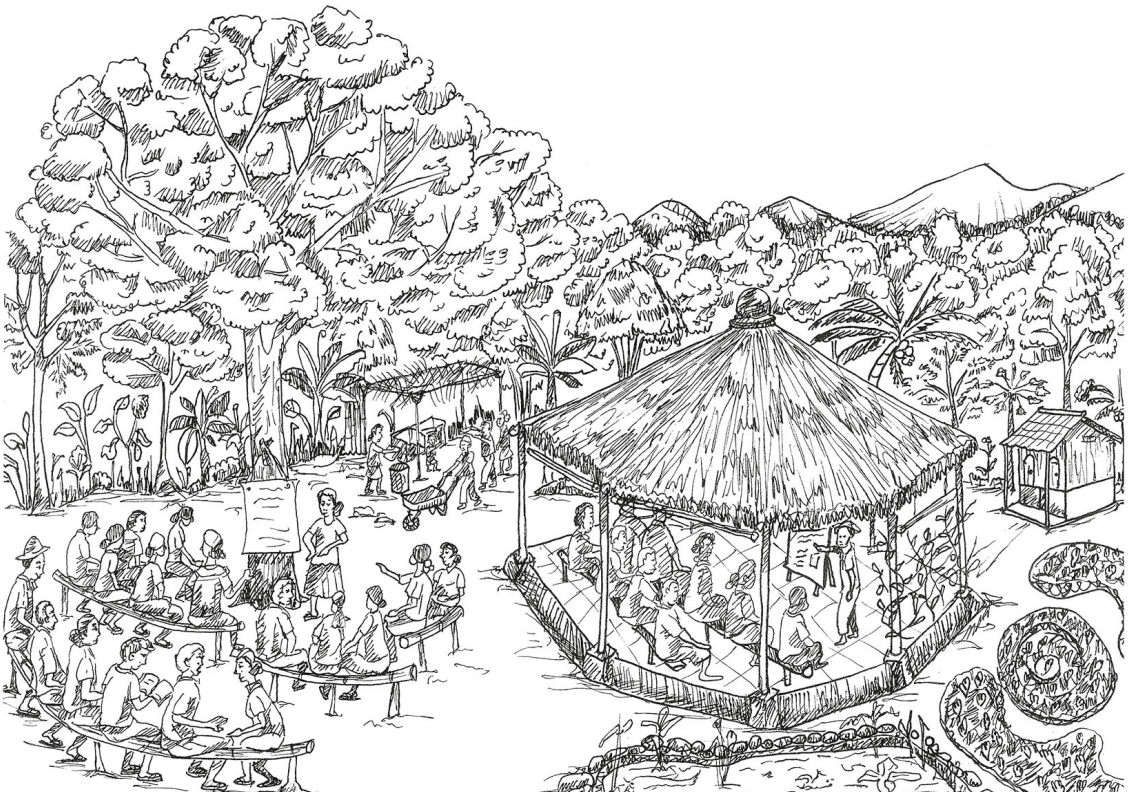
- Ch 1: Permaculture ethics and principles
- Ch 2: Natural patterns
- Ch 3 Permaculture design strategies and techniques
- Ch 4: Urban and community permaculture
- Ch 5: Cooperatives
- Ch 6: Trainers' guide

Chapters 1, 2 and 3 are the foundation for the whole guidebook, for volumes one, two and three. They provide the information to design systems and choose the appropriate techniques. They are vital to understanding how to create a complete system and the subsequent chapters in all volumes continually refer back to them. Designing and planning are part of the first step for all permaculture practice.

Water catchment methods, such as swales, micro-climates and windbreaks, as good examples of basic strategies and techniques, are included in **Ch 3 Permaculture design strategies and techniques** because they are relevant to most other chapters.

Chapters 4, 5 and 6 connect permaculture to people and communities, including practical information on:

- Local economies.
- Livelihoods, cooperatives and businesses.
- Permaculture for towns and urban areas.
- Organising and providing courses for new and experienced permaculture trainers.
- Links to related topics such as disaster risk reduction, food sovereignty and transition towns.

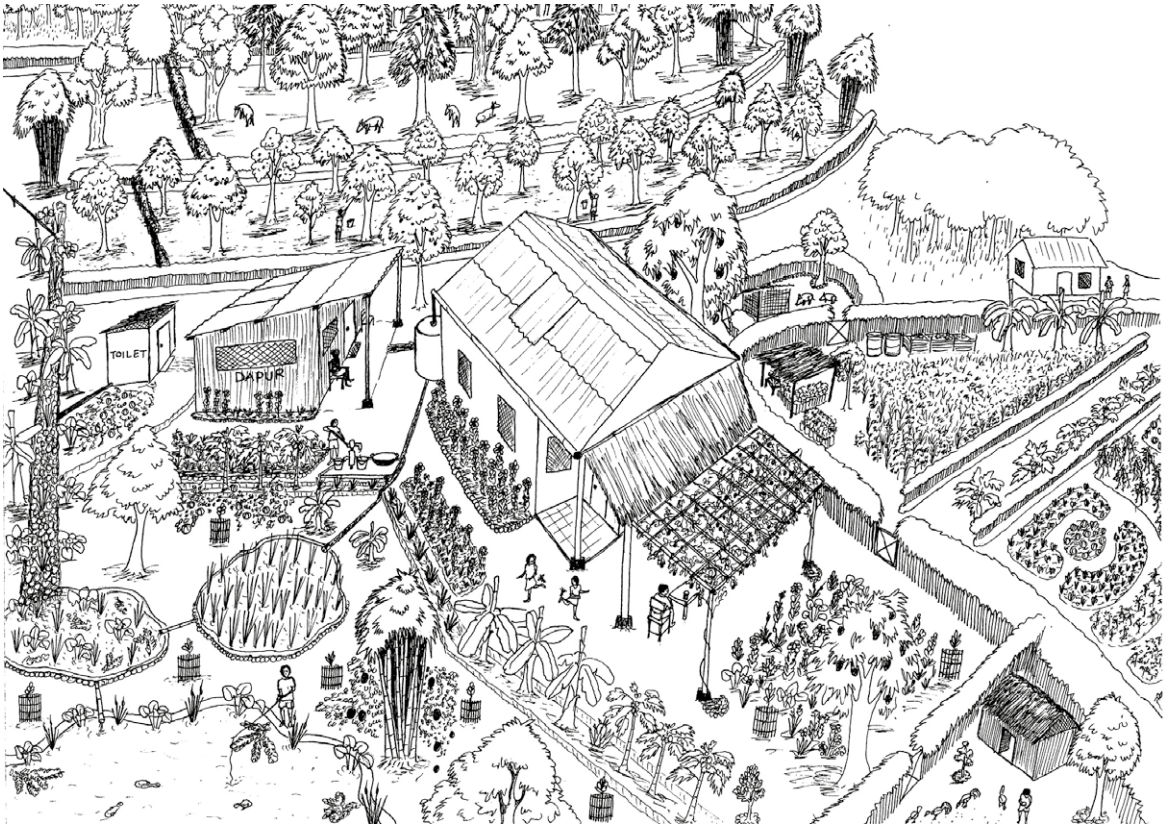


Volume Two: House and Garden

- Ch 7: Houses, water and energy
- Ch 8: Food, health and nutrition
- Ch 9: Soil
- Ch 10: Family gardens
- Ch 11: Seeds and propagation
- Ch 12: Plant nurseries

Volume two includes information that directly relates to families, family houses and family garden production. It also links these ideas to community-scale techniques because families are always part of communities and function better when they are part of a strong community. The chapters all have direct connection with each other, and can be read and used as parts of a single integrated system.

Chapters 9, 11 and 12 are foundation chapters for many chapters in Volume Three and an important starting and reference point. In Volume Three chapters, such as **Ch 14 Integrated pest management (IPM)** and **Ch 17 Animals**, are also important for referencing and linking with Volume Two.

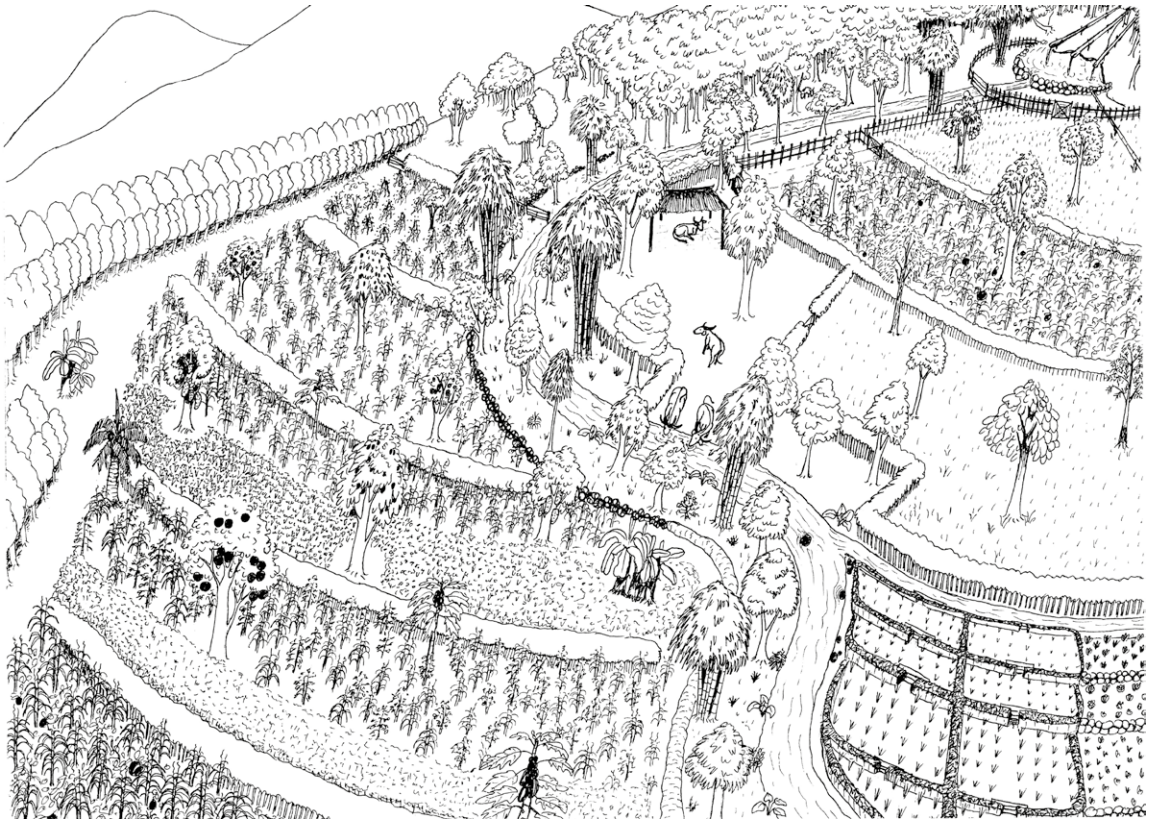


Volume Three: Regenerative Agriculture

- Ch 13: Sustainable agriculture
- Ch 14: Integrated pest management (IPM)
- Ch 15: Trees
- Ch 16: Bamboo
- Ch 17: Animals
- Ch 18: Aquaculture

This volume is called Regenerative Agriculture because the technique and strategies continuously improve the land, production and environment over time. All of the chapters in this volume refer to different parts of tropical agriculture and describe practical steps for achieving good results for families, communities and businesses. The chapters are also integrated with each other, reflected by the content and reference points within the chapters.

Volumes One and Two are important foundations for this Volume, with many chapters containing information vital for creating regenerative and productive agriculture. Volume Three also includes information in the chapters about environmental regeneration; repairing natural ecosystems and how it directly relates to healthy agricultural systems.

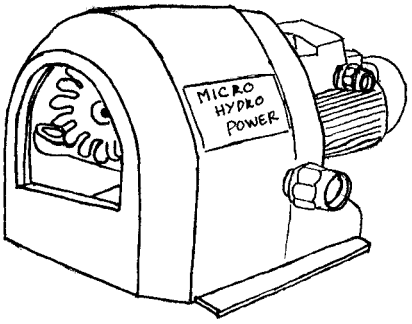


Appropriate technology

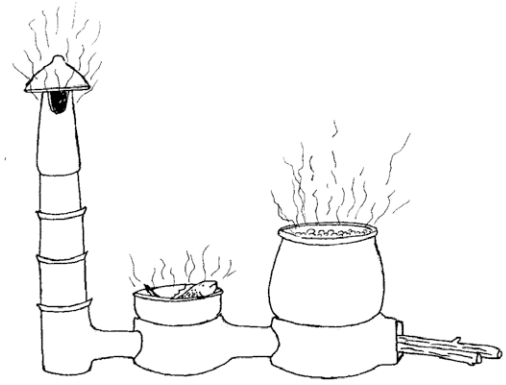
Appropriate technology:

- Is able to be understood and maintained by the people using it.
- Is affordable.
- Reduces energy use — electricity, labour, fuel, firewood, etc.
- Uses natural, renewable energy whenever possible.

Appropriate technology helps to improve the quality of life while allowing communities and countries to protect their land and the environment, and progress to a sustainable future.



In the original guidebook there was a separate chapter on appropriate technology. Instead, in this new edition these technologies as well as many new examples are included in the chapters where they fit best; there is no separate chapter. For example, renewable energy is in the Houses, Water and Energy chapter and clay stoves and solar dryers are in the Food, Health and Nutrition chapter.



We promote thoughtful and useful technological advances, not inappropriate technology that wastes resources just to make money. More and more countries in the world are moving to appropriate technology because it is smarter and more efficient. This is one of the changes we must make to reverse the current environment problems.

Think for yourself

Permaculture is about adaptation and creativity so use this book according to your needs.

If a technique mentions a material that you do not have, try to think of something else you can use to do the same job — improvise. Although the writers of the book have a lot of experience teaching and practising permaculture in tropical countries, we have not been to every household and farm in the tropics and may not know the best way to produce a solution for your situation. Follow the advice you find here and, by applying your knowledge and experience, adapt and improve it to create the best results.

One of the best techniques that permaculture can offer is how to think creatively about problems and solutions.

Use your community and join with other communities

When working with the ideas in this book remember to ask for advice from family, friends and elders in the community. The people close to you can help you plan the best design. Community cooperation and the sharing of knowledge are major elements of permaculture.

Permaculture design techniques and strategies are used in Asia, Europe, the Americas, Africa, the Pacific and Australasia – they are global! By practicing permaculture you become part of an international community. Although people adapt the techniques to suit the climate and conditions in each country, the basic permaculture concepts remain the same.

Many of these techniques and ideas are in books or are available on the internet. Use the reference section to connect you with the huge store of global knowledge. There are many good ideas and techniques being practised all over the world that you can adapt and use in your community — more are invented and used all the time.

Important ideas for implementing permaculture

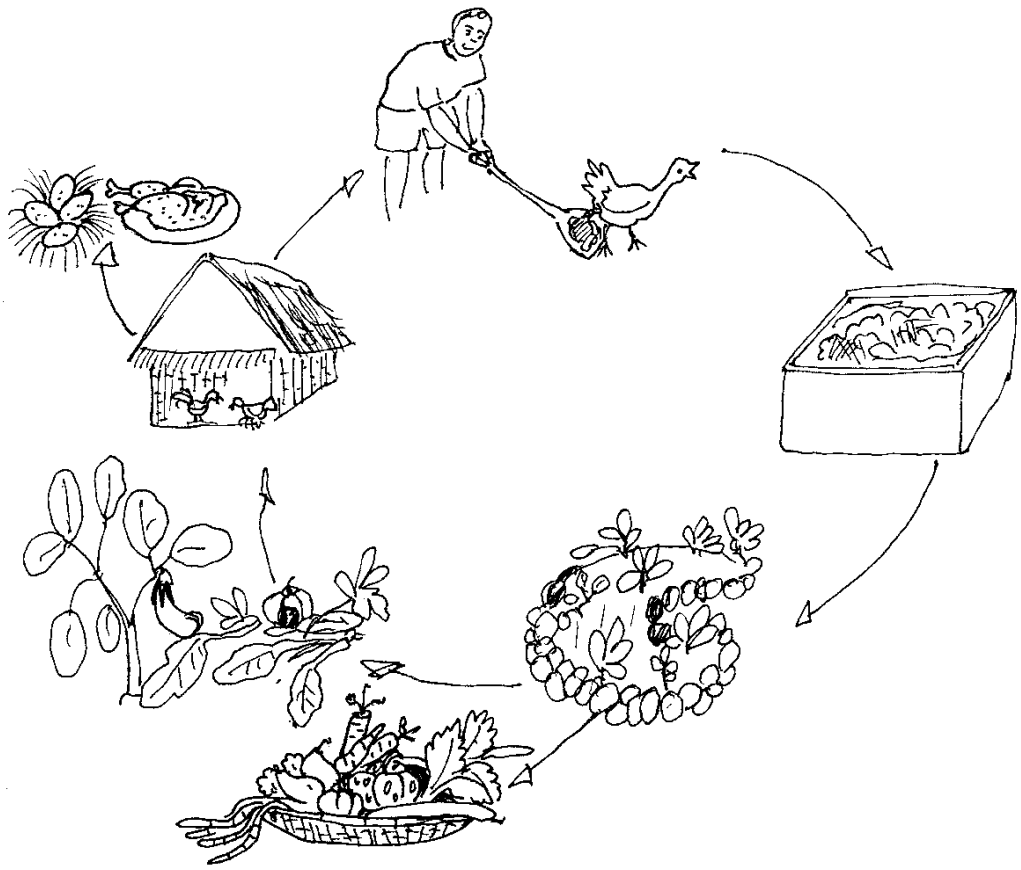
DIVERSITY

Each project, place, community or family that uses permaculture techniques is different. Each has a distinct plan using diverse techniques and various types of plants, animals and building materials. There is also diversity in climate, soil, trees and plants, water supply, knowledge and agricultural history, the shape of the land, etc., and these affect the techniques used. A technique, a plant or animal type that is appropriate in one place may not work well somewhere else, even if that place is nearby. Each situation is unique!

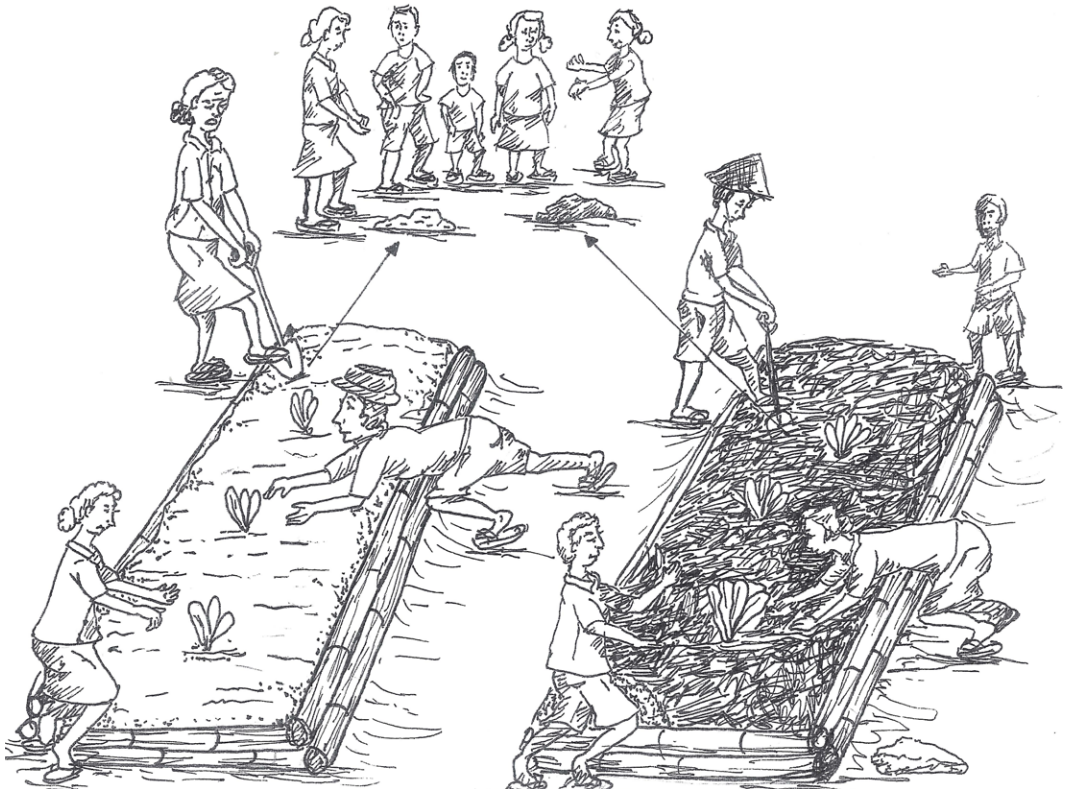
Swapping different bamboo species to increase diversity

When applying your permaculture learning, remember:

- Aim to reduce inputs (outside resources needed) and continually increase outputs (production). Always look for new livelihood opportunities.



- Always use techniques that improve not degrade the land and communities every year.
- Apply the ethics, principles and design methods to guide how to choose and use the techniques. These guides remain the same but the techniques and strategies are different each time.
- Permaculture requires that you use your imagination and adapt to the situation. Remember, conditions always change. Continual observation and adjustment are essential for dealing with different situations and problems.
- Try new techniques and experiment, but research and learn first to make sure they work on a small scale before you try large-scale application. This way you can make mistakes, trying small experiments first to learn what works and what does not. Apply your learning to improve and try again. Community demonstration plots provide a good place for trying new strategies and techniques.



No mulch / Mulch experiments

- When you use strategies and techniques that improve, restore and replenish the land for agriculture and natural ecosystems, the environment works with you and the results can accelerate year-on-year. Good long-term results can occur faster and on a larger scale than you thought possible!
- Step-by-step:
  - Try one thing, e.g. mulching, then another, e.g. animal corrals, then another, e.g. making terraces for vegetable gardens to save water. Do this as your time, money and resources allow.
  - First focus on simple ideas that are the most important for improving basic production and health; these are the first step to applying many other ideas in the future. For example, consider water supply and storage, home gardens, animal housing, compost, compost toilets, small nurseries, and clay stoves.
  - Use the ideas in the Permaculture design strategies and techniques chapter (**Ch 3**) to choose the priorities which will make everything else work better.

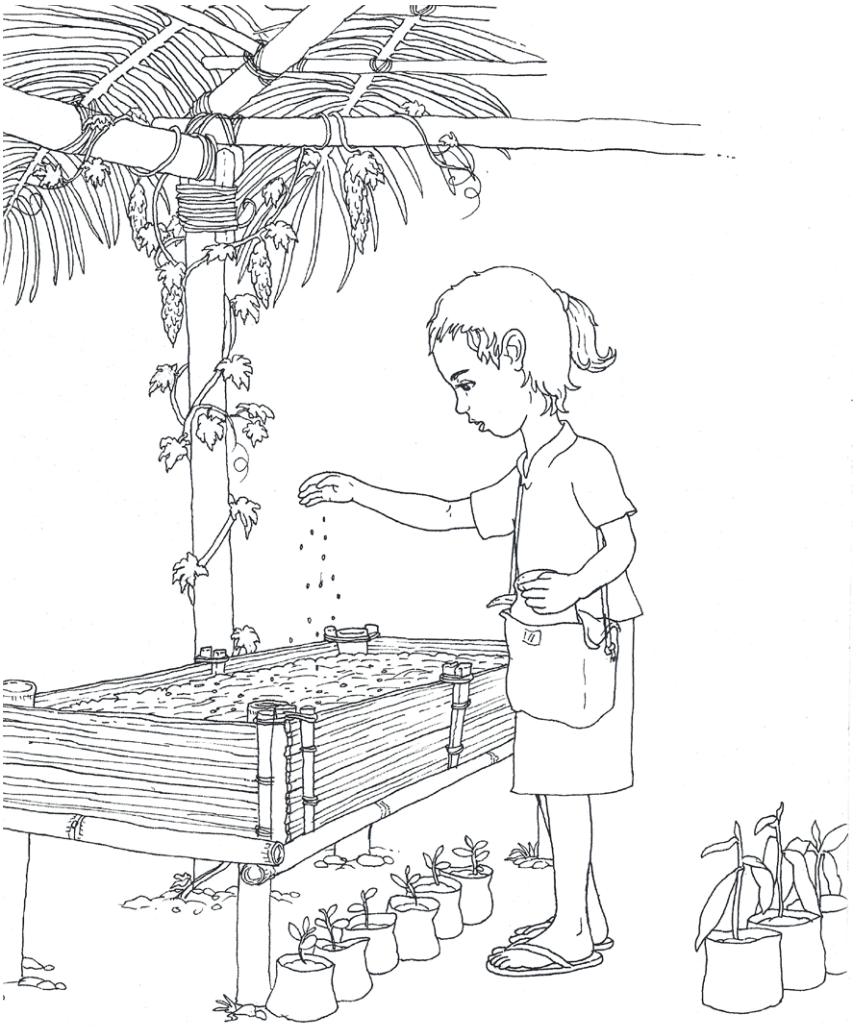
Permaculture techniques are important for reducing disaster risks, especially food shortages, erosion and landslides, flooding, drought, fires and even disease epidemics. Solutions start at the community level, while also requiring a coordinated national plan. Many techniques in this book can be used at both levels: They are easily duplicated in remote communities and integrated into short- and long-term disaster management plans.

Look towards the future. Many of the important community solutions will take time and effort to get good results: For example, improving soils, health and nutrition; building village economies and infrastructure; stopping erosion and; increasing production for fruit trees and in agro-forestry. These steps are the foundation for good health, good production and more secure incomes.

Many important environmental solutions, such as protecting forests, rivers and oceans; stopping erosion and; reducing burning, are not just about obtaining direct financial benefits. The future advantages, including gaining resilience and disaster reduction, are wide ranging and enormous. The work is necessary to protect and grow your community and your country for future generations.

The most important part of using this guidebook is to teach children and encourage their participation as they will carry the ideas into the future.

This book is dedicated to regenerating our earth and creating an abundant and sustainable future for all.



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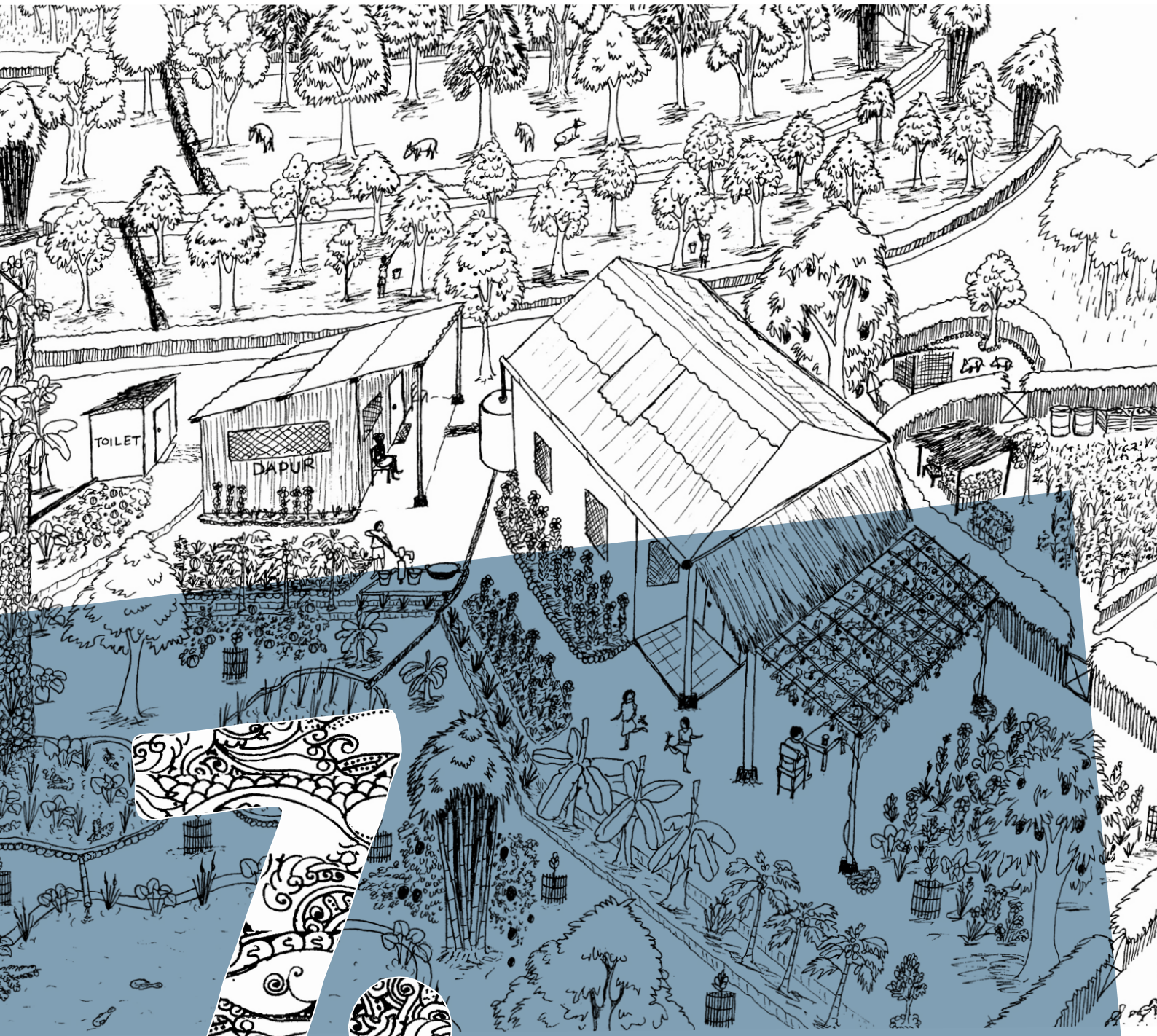

7

HOUSES, WATER AND ENERGY

7. HOUSES, WATER AND ENERGY

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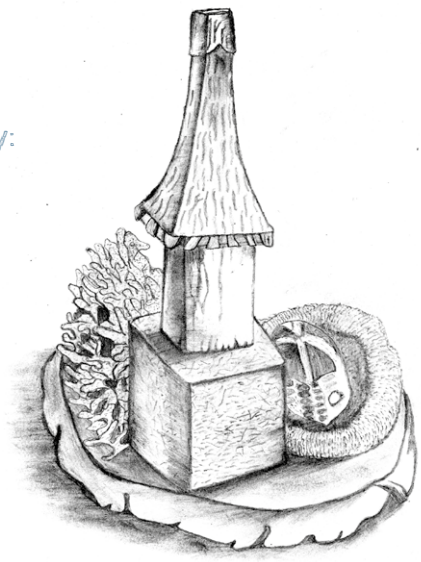
Houses, water and energy are connected to each other and to the broader environment. It is important to understand the connection when building houses, suburbs, villages or towns and for improving existing areas. Always consider the natural environment, including the water and energy sources when you are planning to build or improving your existing house. You can work with the environment to your future benefit, or ignore it to your future disadvantage. This principle is true for every part of the house and living area, including the kitchen, washroom and toilet – each section is part of the surrounding land.

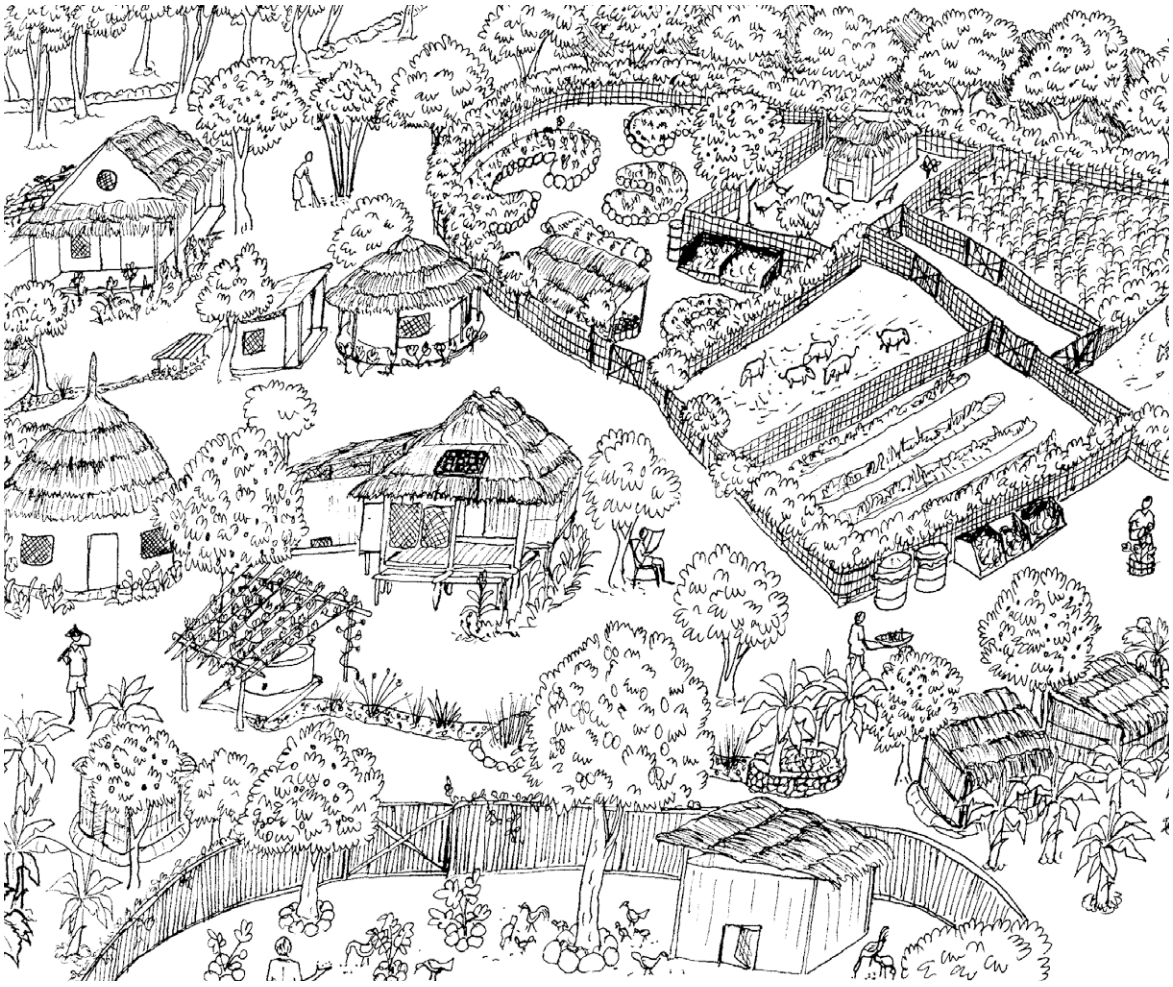
Every house is affected by the land and environment around it.

For example, houses can be negatively impacted by:

- Rainfall, erosion, floods, mudslides
- Wind
- Temperature
- Soil type, rocks, trees
- Water supply

All these factors need to be considered when planning to build, so the houses are appropriate for the environment around them, comfortable to live in, energy efficient and to prevent problems in the future. In the long term it saves work, time and money.





Village houses that minimise negative impacts and maximise positive impacts regarding the natural environment, fulfilling their needs and cleaning/re-using their waste

Every household consumes resources and produces waste that usually contributes to the degradation of the environment around it.

Some examples are:

- Using resources – food, water, firewood or cooking fuel, building materials, medicines, electricity, transport, cleaning materials, etc.
- Creating waste – smoke, rubbish, dirty water and human waste, which can all lead to disease problems

It is essential for the future of all tropical communities to reduce their negative impacts on the environment as much as possible. It is important to minimize:

- The use of polluting coal and oil
- How many polluting materials are used: e.g. plastic products such as bottles and bags, and firewood
- How much pollution is produced: e.g. through burning or buying food with packaging

Communities can limit their negative impacts by:

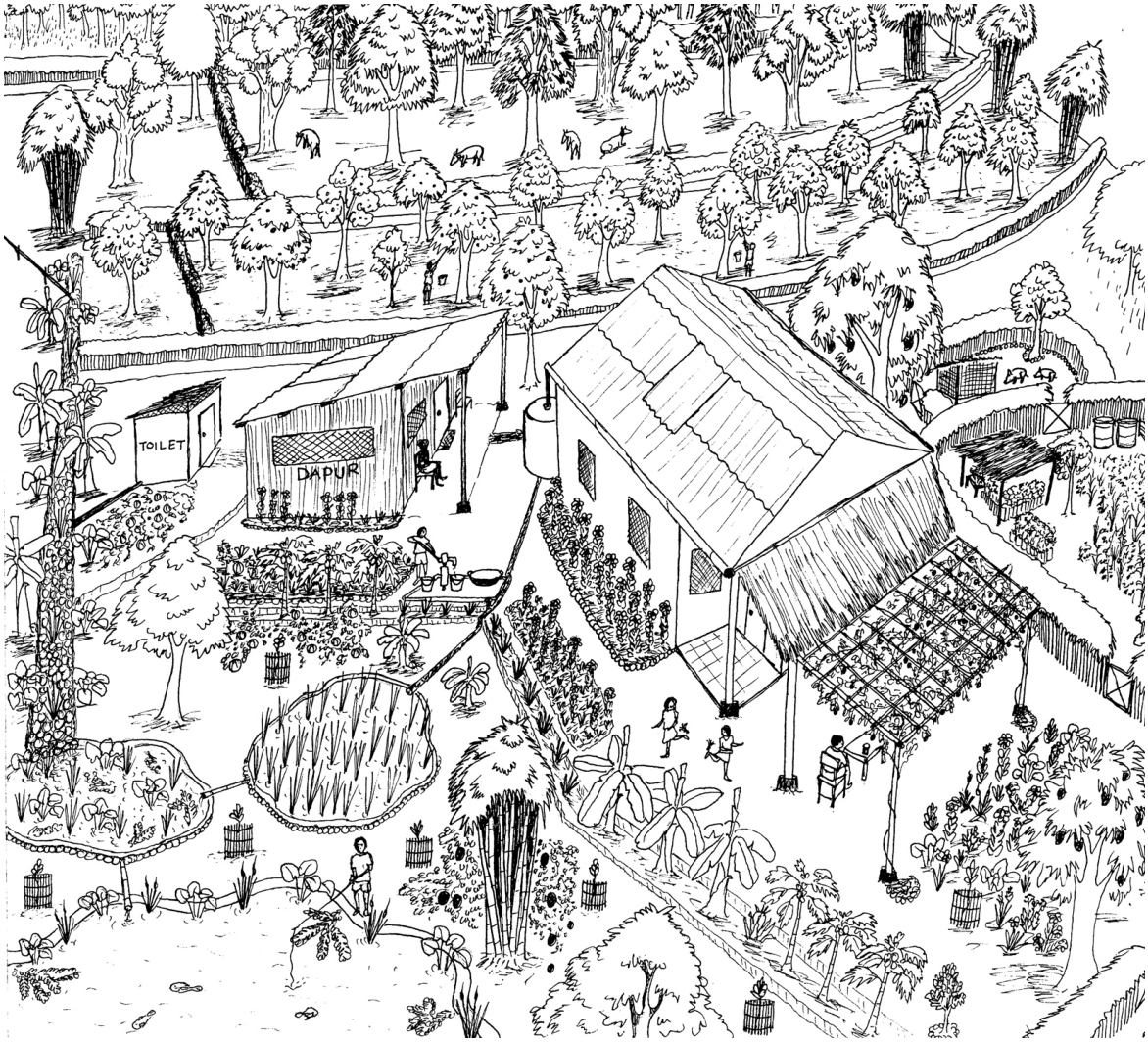
- Reusing waste that is produced: e.g. human waste, leaves, water
- Removing pollutants, disease and rubbish from wastewater before it enters the rivers

The house is part of land design

The house is an important part of the overall design to live sustainably. Understand how to adapt the house to the environment around it and how to integrate the waste products as resources of production. This is true for remote villages, small towns or large cities and for improving existing houses or building new ones. The strategies and principles are the same, but the techniques used depend on each situation. This makes life healthier, and it is better for the environment, reduces living costs and may even provide income.

This chapter explains how to incorporate your house into the land design including:

- Creating a house area that is comfortable, healthy, functional and integrated: e.g. using vegetation and shade, reducing strong winds, improving natural light and ventilation, controlling and using wet season rain from roofs and around the house
- Cleaning and disposing of waste and turning household waste into useful products: e.g. cleaning and reusing water, building compost toilets and showers, recycling and using rubbish
- Making use of natural resources and how to make them last longer: e.g. building with rocks, clay or earth, treating bamboo to kill borers
- Improving and securing a sustainable and clean water supply
- Using renewable energy sources, and minimising energy use and costs through good design
- Integrating the house with food production such as vegetables, medicines, fruit, small animals and fish

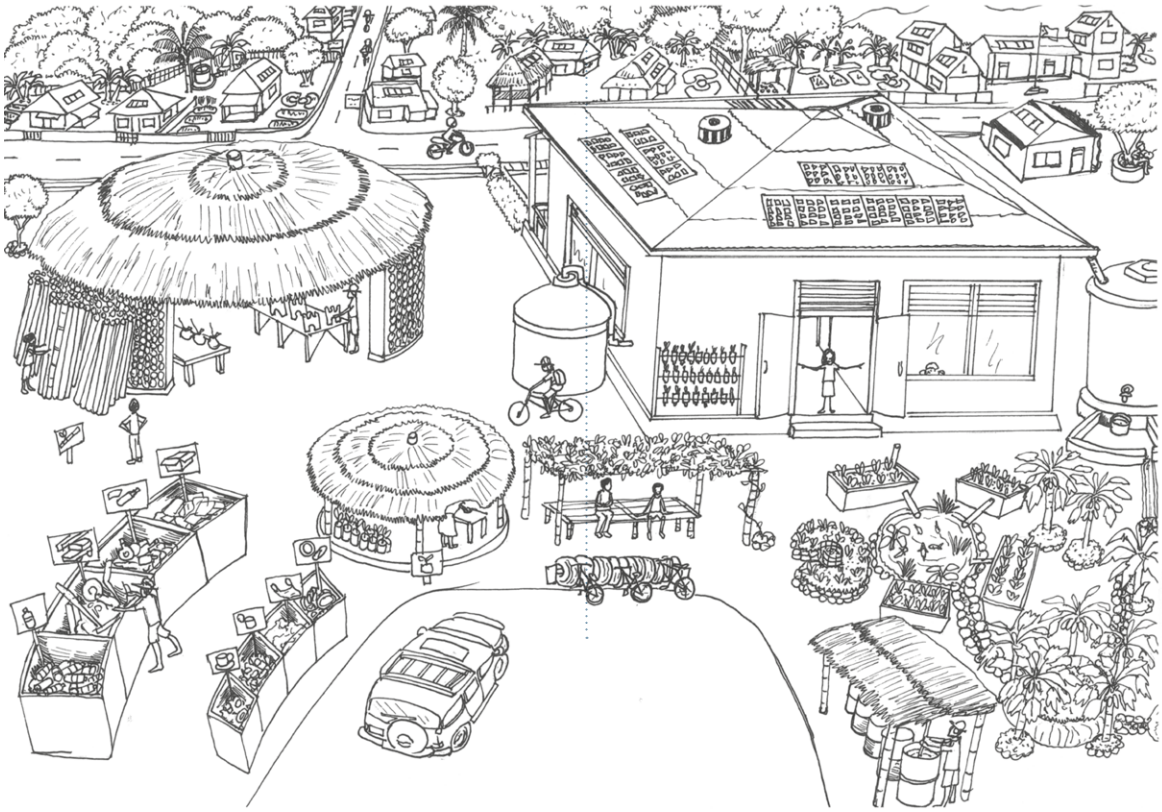


A sustainable healthy house with wastewater management that is integrated with agriculture, animal production and the surrounding environment.

COMMUNITY IDEAS

Individual families can improve their house and living areas. There are also many ideas for improving houses and living areas that can be organised, applied and managed at the community level. Many improvements are better, cheaper and easier to maintain if the community works together, especially in urban areas.

This is achieved through the process of community meetings, agreement and action. It is important that everyone has input and that everyone in the community understands and has ownership of the projects to assist and develop the community. It is also important to work with the government to improve the situation at the community, regional and national level. Read more in Urban and Community Permaculture (**Ch 4**).



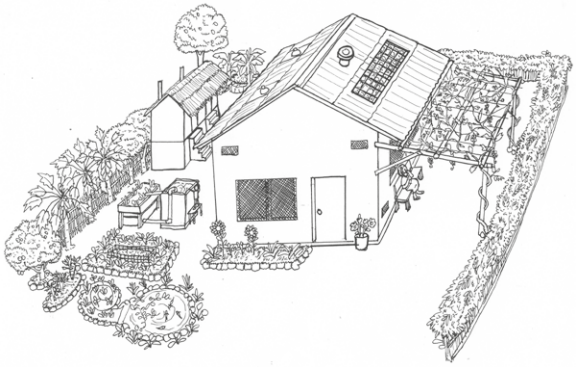
How do you create a healthy house?

A healthy house is practical, long-lasting, uses minimal energy, improves life and reduces costs. This is achieved by using smart designs that take natural factors into account, using the benefits and minimising the negative impacts. It is also important to have a house to be proud of, creating one that looks beautiful inside and outside. These ideas can all be combined.

Making your house better does not have to cost more money. In fact many ways to improve the quality of a house and life in it save money and provide extra resources for your garden and animals: e.g. fertiliser for fruit trees, water for vegetables, food for animals, less firewood to buy.

All of the strategies and techniques in this chapter apply to new houses and can be used to improve existing houses.

Original house



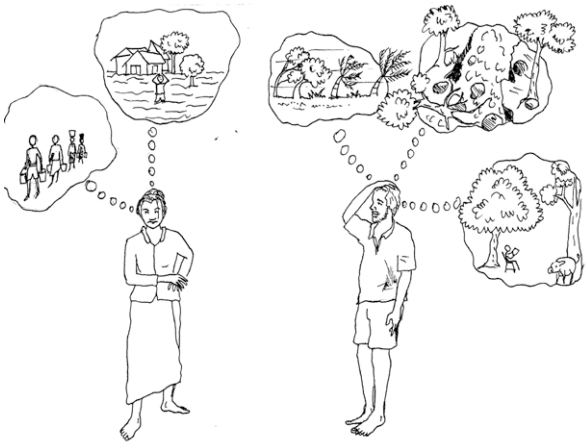
Improved house

1. House location

Finding a good location for your house is essential and this must be considered as a community. If it is not possible to choose the place or the house is already built, use strategies and techniques to improve the location so it can be as safe and comfortable as possible.

Think about:

- If the house is located on a hillside, consider the possibility of mudslides.
- If the house is on flat land, consider flooding. It only needs to flood once in five or ten years to destroy the house, and kill animals, crops and even people. It is possible to prevent minor flooding with good water catchments and drains.
- Where do strong winds come from? Can they be avoided or are windbreaks needed?
- Where is the closest water source? What sources are there, where can water be brought from and how can it be collected and stored?
- How much sunlight is there? Are there any shade trees?
- Where does the sun track across the sky in summer and winter, and how does that impact on your house? This is especially important in mountainous areas and for creating cool areas for comfortable living.



Thinking about house location issues

2. Reduce risks

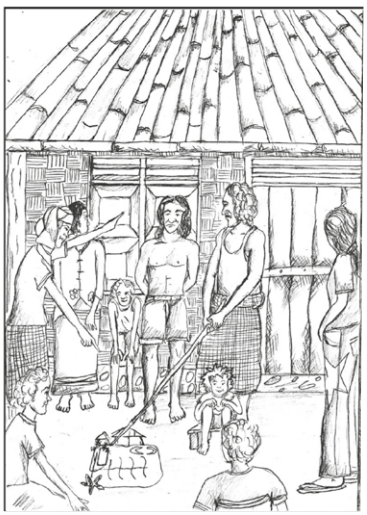
- **Stop erosion and reduce the chance of mudslides and flooding.** Reforestation of mountains and along the riverbanks is the best long-term solution to reduce flood risk. Flooding may still occur, but the frequency and severity are much less with good land management. Good waste management is also important, as sometimes flooding is caused by rubbish in the rivers.
- **Reduce the chance of fire.** Keep areas close to the house clear of flammable vegetation. Fires move much faster up hill and with the wind. Use firebreaks (Permaculture Design Ch 3) if fires are a risk.
- **Reduce damage to houses from strong winds.** Do not build on top of hills if possible and plant trees to create windbreaks.
- Houses built from earthbags or bamboo are much more earthquake proof than other materials. Bamboo is ideal for hotter coastal regions and earthbag houses for mountainous cooler regions.

COMMUNITY IDEAS: PREVENTING DISASTERS

Preventing disasters is a strategy for families, communities and governments.

- Rivers and river banks must be protected to reduce flood risk. Trees, bamboo and grass along the river banks reduce erosion and flooding. Reforestation of community land with productive deep-rooted trees and bamboo reduces the risk of landslide. Traditional ceremonies to protect land using community agreements and land laws, such as *Tara Bandu* in Timor-Leste, protect community land and trees.
- Stop putting plastic rubbish into the rivers – this often causes flooding further down the river when all the plastic builds up and blocks the water flow.
- Earthbag houses have proven to be excellent for earthquake areas and would be great for community buildings too. Government assistance, as well as working with organisations to help with resources and finance, enables more families to build with earthbag technology. It saves a lot of money and problems in the long term.

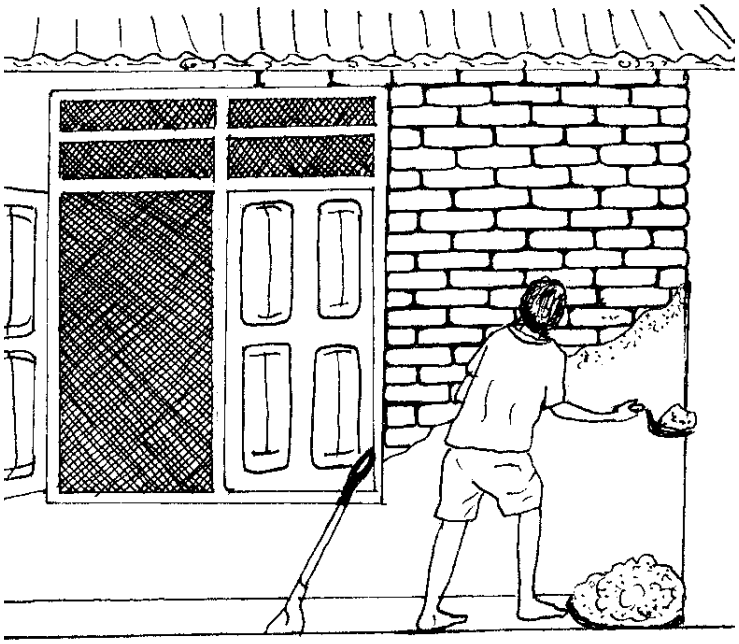
3. Suitable for the climate



There are different climates in tropical regions. A house design should be suitable for the area where the house is built. For example, mountain areas get cold at night. Therefore use construction materials to stay warm at night, such as rock, earthbag, mud brick or brick, and build a house that can be closed up to keep the heat inside.

Coastal and low altitude areas are much hotter, so materials, such as bamboo, panels made from palm-leaf stalk and a grass roof, stay much cooler than cement blocks. An open-plan house with an outdoor living area and windows that can open to allow airflow is much more comfortable. However, if security is an issue, especially in larger cities, design plans need to include lockable rooms.

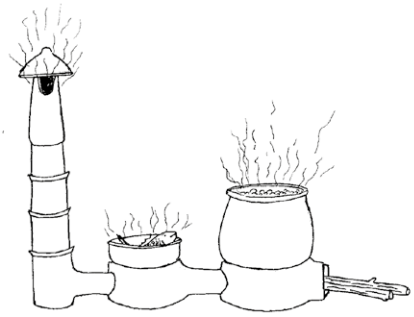
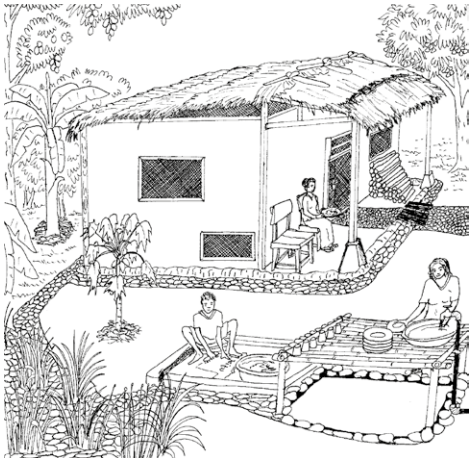
A house design for tropical areas between the coast and mountains can combine rooms that stay warm at night with open areas to reduce the heat during the day. Outdoor shade structures improve the house and surrounding area a lot, especially on hot afternoons. Trees around the house moderate the climate by providing shade, reducing winds and cooling the air. Trees also provide other benefits such as attracting birds.

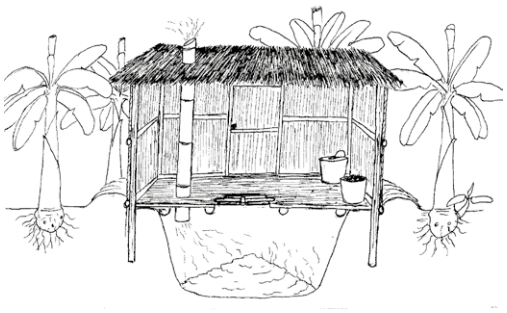
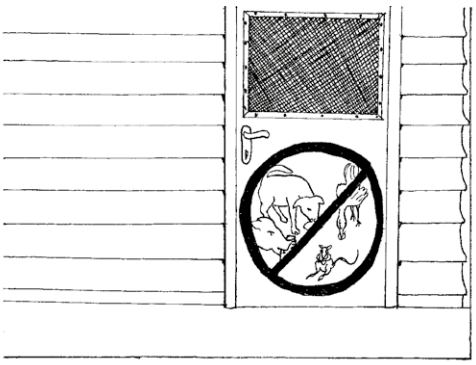
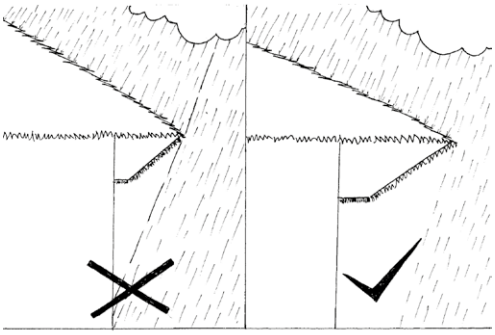


Rendering clay bricks

4. Good health and disease prevention

A well-designed and well-built house area reduces or prevents sickness. This is especially true in the kitchen.

PROBLEM	SOLUTION	
Smoke causes breathing problems, lung diseases and doubles the risk of childhood pneumonia.	• Include good ventilation in the kitchen. • Fit a chimney (pipe) to draw out the smoke. • Cook with stoves and ovens that produce little smoke. • Use biogas.	
Mosquitoes cause malaria, dengue fever and many other diseases. They breed in stagnant water.	• Do not let water collect in containers around the house or in pools around the garden. • Cover any tanks or washroom water. • Put insect screens on the windows. • Hang mosquito nets over sleeping areas.	
Diseases can spread through dirty washing areas.	• Build a good, easy-to-clean washing area. • Ensure there is fast drainage of wastewater. • Install a filter system to clean the wastewater after it leaves the washing area.	

Diseases can spread from open, dirty toilets.	• Composting toilets and toilet rooms prevent animals and insects from eating or touching human manure. • Compost toilets kill bad bacteria in human manure and turn it into high-quality fertiliser for fruit trees. • Use toilets instead of openly defecating by rivers and other areas. • Ensure the toilet is hygienic and well ventilated.	
Mice, rats, dogs, cats, cockroaches and flies, etc. can spread diseases, especially if they eat food and/ or manure.	• Keep all food in containers or bags that prevent pests from reaching it. • Prevent animals from entering the kitchen. • Build an easy-to-clean house. • Wash your hands with soap before preparing food and eating meals, and after using the toilet. • Dispose of food waste daily into a compost system or give it to animals.	
Mould and damp walls can cause chest infections and breathing problems	• Keep the floors and living areas dry. • Make sure the roof does not leak. • Keep rain away from the walls with a roof that is much wider that the walls. • Good ventilation reduces dampness. • Good drainage above and around the house prevents water from collecting and causing problems.	
Burning rubbish produces smoke that causes many health problems.	• Recycle as much rubbish as possible. • Burn the rest (but never plastic) in special area away from the house and children. • Do not use plastic bags!	

The chapter explains all of these solutions with illustrations.

5. An easy-to-clean house

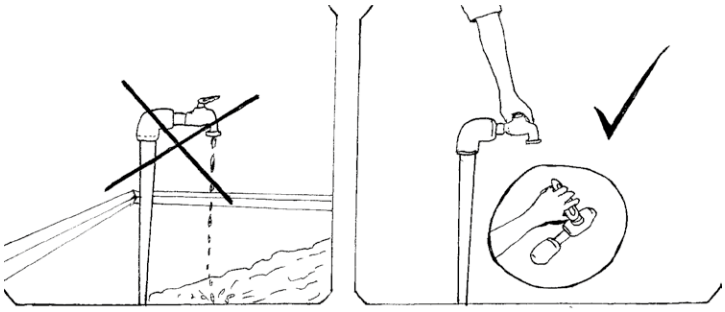
A house that is easy to clean reduces housework, improves household health and benefits the whole family. A cement or stone and cement floor is easier to clean and better for people's health. Walkways made from small or large stones between the kitchen, house, washroom and toilet reduce dirt, mud and disease risks.

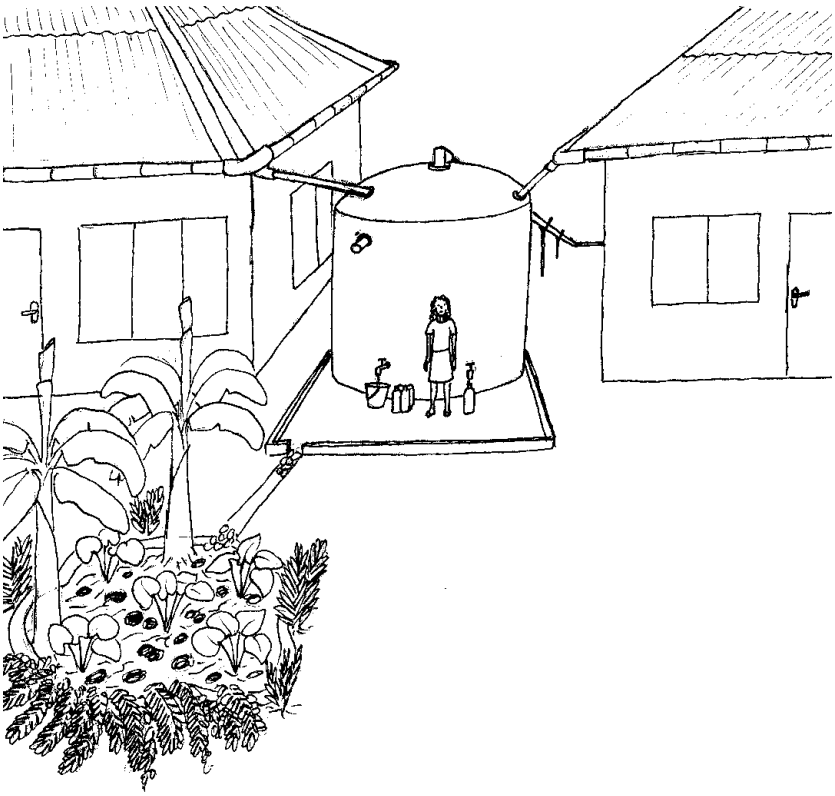
6. Efficient water use

Water is a precious resource that is often hard work to collect. This chapter gives many ideas for collecting and storing water, but it is better to use less water in the first place. Even in towns and villages with piped water it is very important to use only what is needed to make sure there is enough for the future.

Water-saving ideas for households:

- Always turn off taps after use. You can use spring taps that turn themselves off.
- Make a composting toilet – it uses much less water.
- Clean and reuse all the kitchen and washing water (wastewater) in the vegetable garden or to water other plants.
- Use buckets and sinks for washing; do not leave the water running continually while washing.
- Repair leaking taps and pipes immediately.





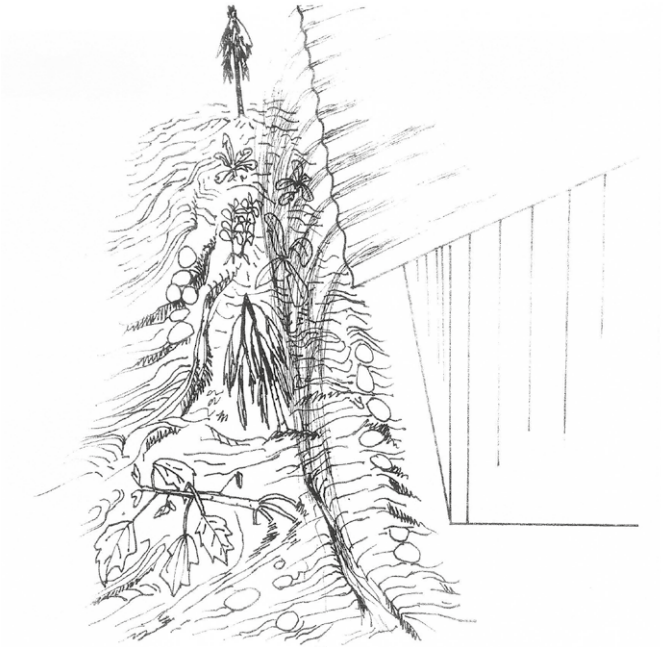
Water collected and used efficiently with the overflow being used productively

7. Good drainage

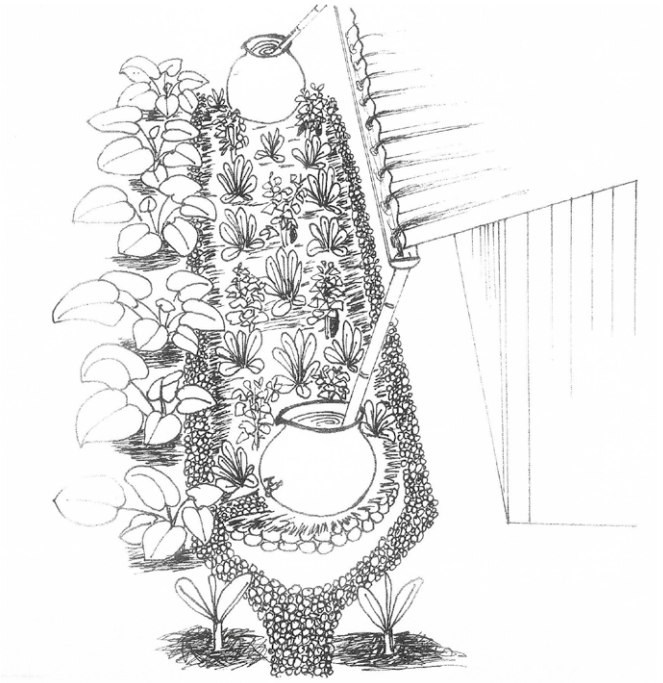
For houses built on land near hills or raised areas, it is important to divert the water in big rains. Dig trenches and swales in the land above the house to catch and channel rain water. Plant grass, bamboo and trees straight away to hold and protect the swales and trenches. You can then the channel the water past the house into ponds, banana pits or vegetable gardens.

Include a layer of gravel under the house's floor slab to prevent moisture seeping through the cement or rock floor.

A shallow trench around the house filled with rocks can catch the rain that runs off the roof. Use the soil from the trench to make the ground higher on the side closest to the house. This helps to keep the house dry in the wet season. Dig the trench so the water runs slowly away from the house towards vegetable gardens, banana pits, swales, etc.



No drainage

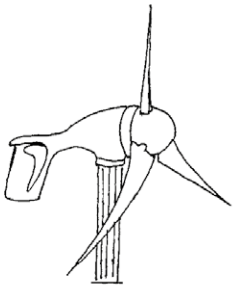


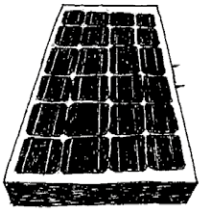
Good catchment and drainage

8. Smart energy use with renewable energy sources

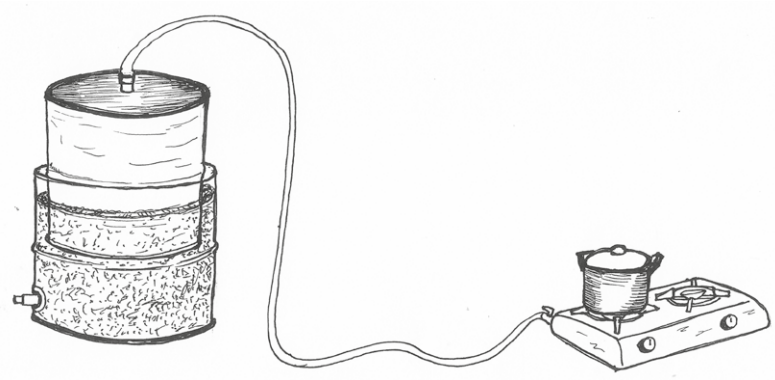
Fuels, such as wood, kerosene, electricity, generators, gas, petrol, oil and even candles, all provide energy for household needs including cooking, lights, music, cars and more. Burning oil and petrol causes pollution and they will become more and more expensive because the supply will not last forever.

It is very important that people all over the world reduce their energy use and change to renewable energy. Solar panels, micro-hydroelectric generators, biogas systems and wind generators (all explained later in the chapter) are examples of renewable energy suitable for tropical countries. This chapter also looks at how to reduce the amount of energy and electricity you use through:





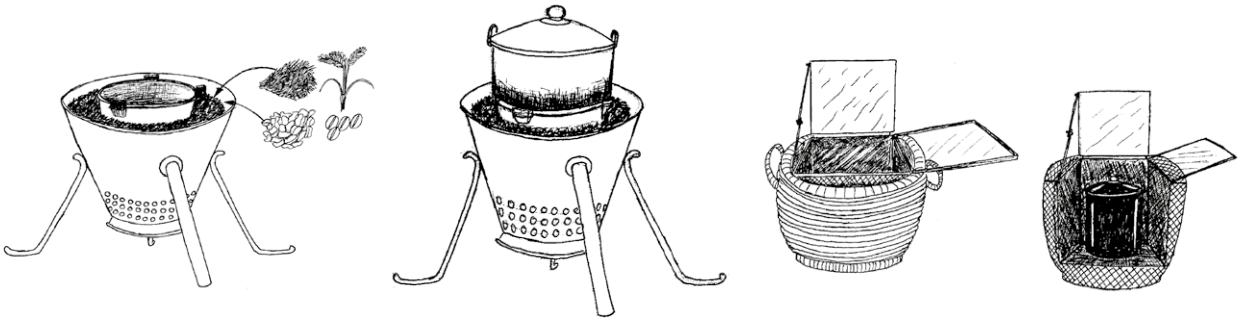
- Good ventilation
- Natural light
- Insulation
- Good house design to reduce or increase direct sunlight on the walls as needed
- Appropriate building materials
- Integration with trees and gardens



Simple biogas system

Using stoves and ovens that need less or no wood or using bamboo waste or gas is very important. (Read Food, health and nutrition **Ch 8** for many examples.) People are cutting down trees for fuel very quickly, much faster than they are planting them. It is already a big problem for the environment, and it will get much worse unless people change the fuel they use.

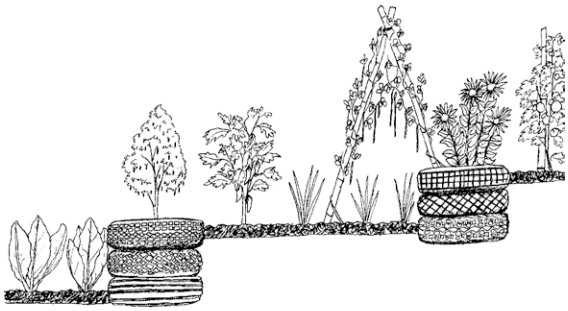
There are many places in the world where people walk all day just to collect enough firewood for their needs. Is this the future we want?



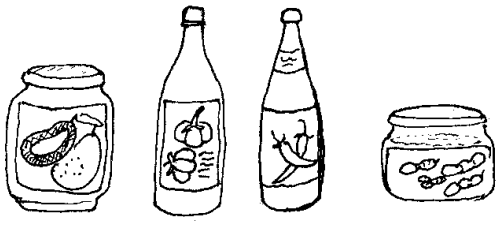
9. Waste management and recycling

For a truly sustainable earth there should be NO waste! The cycle in natural ecosystems turns everything into resources, so there is no waste. We must copy that cycle and create systems for our communities where we do the same – our aim should be not to create waste in the first place!

Most people throw away food scraps, wastewater, human manure and urine, plastic, paper, tins, cans, bottles, ash, leaves, batteries, old car and motorbike parts, old oil and metal, etc. However, if we value these products as resources, they are no longer wasted and can be reused. Food scraps become compost or animal food and by cleaning household wastewater it can irrigates plants. Human manure and urine can become compost for trees. Bottles and tins can be reused and if people collect them with plastic they can be recycled and turned into new products.



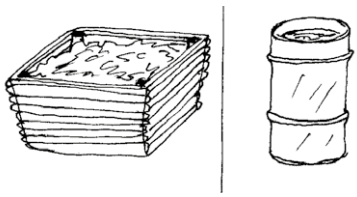
Using old tyres to create terraces



Reusing old bottles to make sauces and preserves

Waste should only be what we cannot reuse, repair and recycle!

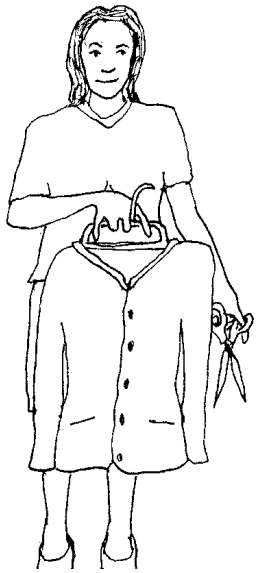
Waste is also pollution, such as chemicals, contaminated water, noise, excess light and smoke from factories that make products and trucks that transport them. We contribute to this when we buy products and use energy. Therefore we ALL need to reduce how much we buy and try to make or buy environmentally friendly products as much as possible.



Make compost and liquid compost instead of buying chemical fertilisers

Steps you can take to minimise waste:

1. Reduce the amount of waste you create. This is the most important step.
   - Do not use plastic bags or buy products with a lot of plastic or other packaging; use cloth bags or baskets instead.
   - Buy whole food, not processed and packaged food (as good waste management leads to good nutrition too!).
   - Minimise your energy use through good house design and good habits.
   - Buy good quality products that last a long time, even if that may mean spending a bit more money than you really want to. You save money in the long term.
   - Buy cotton and natural fibre clothes not those made from synthetic materials.
   - Use natural body products such as soap and deodorant.
2. Reuse products, such as bottles and cans, and avoid buying products that are designed to be used only once; for example, plastic cups, plates and containers.
3. Repair products instead of throwing them away.
4. Recycle what you can in your house or in community rubbish facilities.
5. Responsibly dispose of waste that you produce.



Repair clothes rather than throwing them away

Plastic packaging, bags and drink bottles are some of the biggest waste problems; they are choking our rivers and oceans, causing enormous problems for aquatic life.

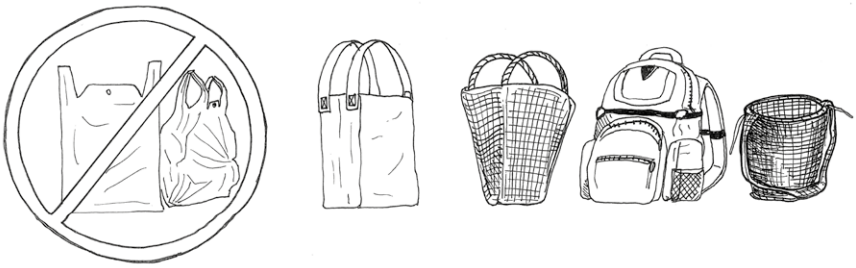
EVERY SECOND OF THE DAY PEOPLE USE 160,000 PLASTIC BAGS AROUND THE WORLD!!! THAT MAKES ALMOST 10 MILLION BAGS EVERY MINUTE!!!

And most plastic bags are not reused: they are just thrown away or burned.

That equals:

- 576 million plastic bags per hour
- 13.8 billion plastic bags per day
- 96.7 billion plastic bags per week
- 5 trillion plastic bags per year!!!

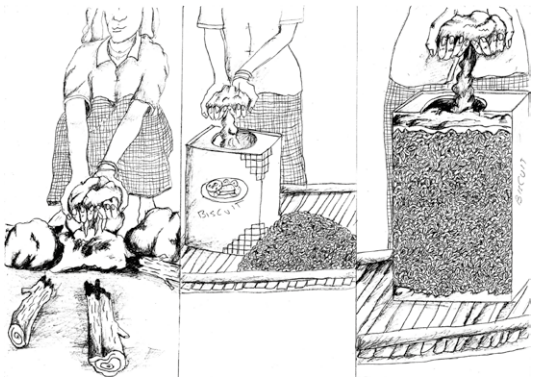
One solution is changing to natural plastics made from plant waste. However, the best solution is to not use plastic bags in the first place! Carry reusable bags, refuse plastic and change your habits today!



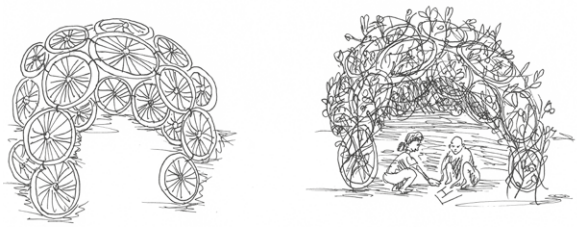
You benefit from being responsible about what you buy and use, it protects the environment and reduces climate change. Future generations depend on us being responsible now.

Good waste management is separating out the waste and turning most of it into useful products.

- Garden waste, such as leaves, food scraps, wood ash, paper and manure, becomes compost, liquid compost, animal food, mulch, fertilisers, etc.
  - Wastewater can run into the garden via water trenches for irrigation.
  - Compost toilets turn human manure into fertiliser.
- Discarded items can be products for nurseries and gardens.
  - Plastic containers store seeds.
  - Tins make good seedling containers and watering cans.
  - Old tyres, cans, broken buckets, etc. can be used in a nursery for seedling or flower containers.
  - Fridges and freezers can be turned into large garden beds.
- Old paper can become recycled paper.
- Plastic bottles have many, many uses.
- Clean glass bottles can store honey, oils, sauces, etc.
- Old plastic bags can be reused. When they have holes they can even be woven together to make strong carry bags!
- Art, particularly sculptures, make use of all sorts of junk.
- Shoes, handbags, carry bags, wallets and more can be made out of many different recycled materials.



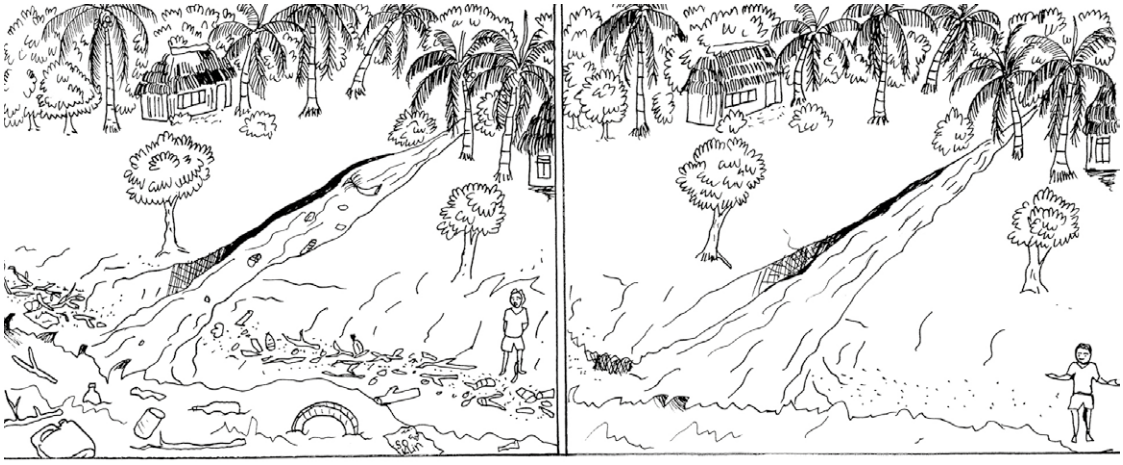
Reusing biscuit tins and ash for storing seeds



Dome structure made from old bicycle wheels

Bad waste management is burning everything, not preventing animals from eating human manure and letting wastewater lie on the ground.

Worse waste management is to dump rubbish in rivers! It pollutes the rivers and oceans, kills fish and other aquatic animals, causes flooding and other big problems for the future. It also looks and smells ugly and spoils beautiful environments.



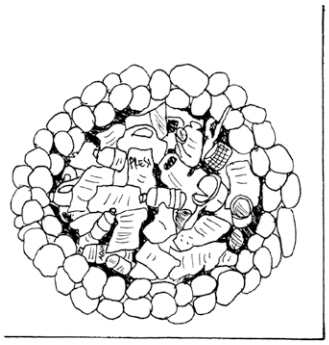
Which future do you want?

Burning waste

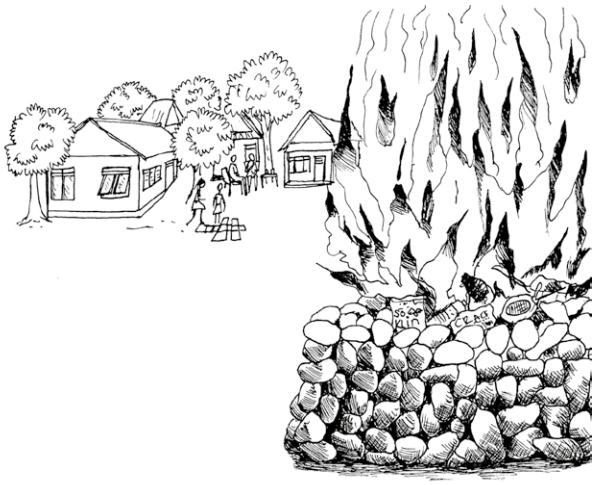
Some waste may still need to be burned. If rubbish is burned quickly at a higher temperature it creates less smoke and is better for people and the environment. NOTE: Plastic should never be burned outside an industrial incinerator at very high temperatures because it produces very toxic smoke which is dangerous for your health and the environment.

Building a circle of rocks around an area creates a place to burn rubbish. Put the rubbish into bags and store them in the burning area until you can burn all the rubbish at once (but make sure you stop animals from getting into the bags and spreading the rubbish around). This creates the heat which reduces smoke and pollution.

- Cover the top until it is burned to stop dogs from entering.
- Leave holes in the rocks to let air through to help it burn quicker at a higher temperature.
- Build the rock circle away from the house.



Rock burning circle - view from above



DO NOT let children stand near the smoke and breathe it in. It is poisonous!

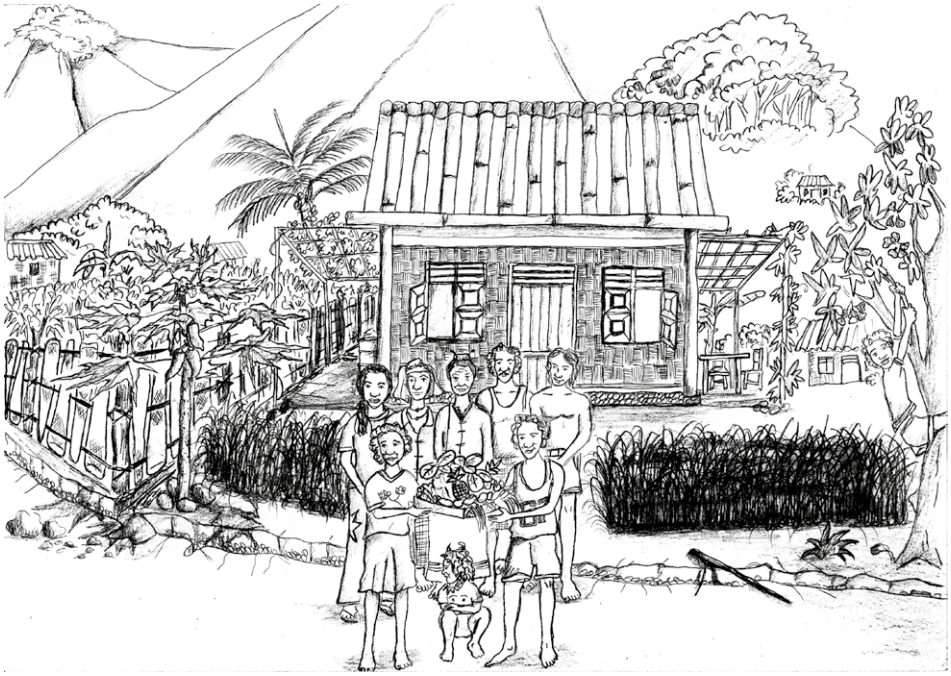
Read Urban and Community Permaculture (**Ch 4**) for community and large scale waste management strategies such as recycling metals and glass, turning plastic into building materials and dealing with chemicals and other dangerous waste.

Building a house

Start with a design

Use the healthy house factors listed previously as guidelines to help create the design. Include everyone in the family in the designing process to address all the needs. Women spend more time around the house and therefore have important ideas on how the household needs can be met, and how to deal with health concerns and cleanliness. This includes which materials to use and how to make the house beautiful. If all the needs are met it saves time and effort, and improves the lives of all the family. The design should consider any disabilities in the family to make lives easier and allow people to participate fully in daily activities.

The plan for the house area needs to include trees, gardens, outdoor living areas, shade structures, drainage, etc.; for example, a shade structure for growing vines cools the house, provides an outdoor sitting area and food such as grapes or passionfruit.

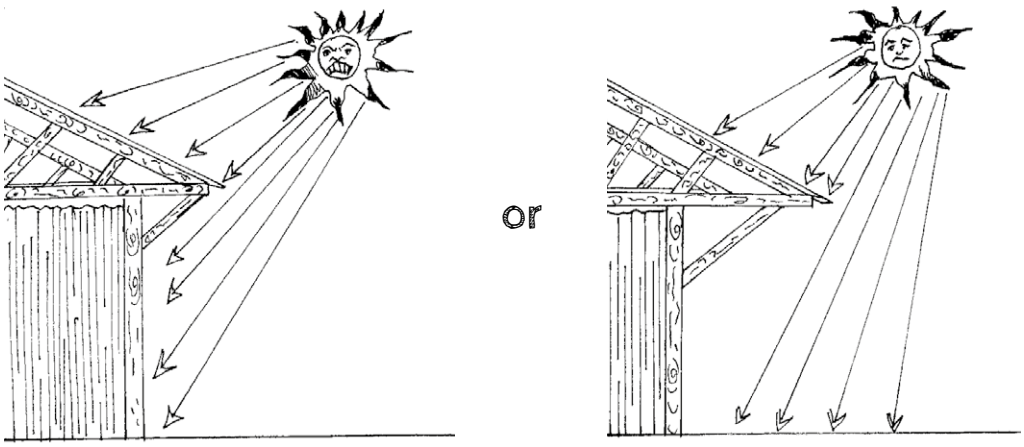


House designs

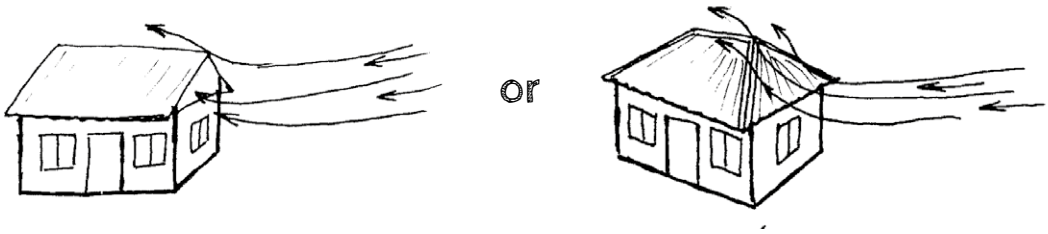
To create a great design, the house needs to be culturally appropriate, be suitable for the climate and use locally available materials. Each region and sometimes towns have their own designs for their traditional houses. These houses reflect the climate and the building materials available. Cement brick houses are generally based on a modern, easy-to-build method. They are often not suited to the climate, especially on the coast. While it is important to choose materials that suit the climate, the design of the house, including the shape and size, also makes a big difference to the temperature, comfort, strength and durability of the house. Appropriate materials and a good design are essential for disaster prevention. A change from the usual box shape house also makes it more beautiful!

SMART IDEAS FOR HOUSE DESIGNS:

- Create indoor and outdoor living areas.
- Traditional techniques can be combined with modern designs.
- Room placement is important. Rooms that face the afternoon sun are the hottest in the house at night, for instance, a bedroom that gets the afternoon sun – in cold areas this is good, but not in hot coastal areas.
- A verandah or shade structure built on the west side of the house (where the sun sets) keeps the house much cooler during the afternoon, so it is not so hot at night. Planting shade trees and bamboo on the west side also helps. In colder areas plant deciduous trees to let in sunlight during the dry season.
- A raised house area on poles with an open ground level area underneath is common in coastal and flood-prone areas because it improves ventilation a lot and reduces the risk of the house flooding.
- A roof that is wider than the walls reduces the amount of direct sunlight on them. This cools the house a lot in hot areas.



- A curved wall is stronger than a straight one! It looks better too!
- In strong wind areas, a four-sided rather than a two-sided roof helps prevent wind damage. This is because the wind blows over the top instead of underneath, which can lift the roof off!



- Create space! This means awareness of and building in space for people to move, making it easy to get around and creating the feeling of comfort without being cramped or cluttered. This can even be achieved with small houses, especially if indoor and outdoor areas are combined.
- The design can also incorporate future additions and changes. For example, if you can only build a small house at first because of having limited materials or money, include future plans for house extensions in the design.

House-building materials

Traditional house-building materials include wood, palm-leaf stalk panels, bamboo, clay, stone, grass and palm leaves.

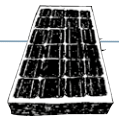
Modern house-building materials include cement blocks, wood, bamboo panels, earthbags and tin sheets and metal.

Materials can be used separately or combined, both modern and traditional. Bamboo, clay and stone are excellent building materials if used properly. The chapter explains some simple ideas and different techniques for using them but long and detailed information is beyond the scope of this book. Reference books and internet sites for building materials and construction designs are in the reference section.

CLAY

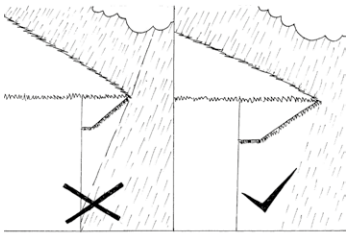
When built properly a clay brick or clay wall house lasts for many years. There are clay and mud brick houses in different countries that are 100 to 200 years old or more! In most tropical countries there are areas that have excellent clay for building clay bricks and mud walls. Clay houses stay much cooler in the hot weather than cement block houses. Good ventilation is important during the day as clay walls store some heat from the sun. At night the clay walls slowly release the stored heat, naturally keeping the house warmer. Clay houses are best for areas that are cold at night.

Clay walls are made by mixing clay, water and some dry grass. Build the wall starting at the base and slowly adding more of the clay mixture. You can also use the clay to make bricks by mixing it with water (and a small amount of dry grass). Put the mixture into a mold and press it, remove the mold and dry the bricks. It is a similar process to making cement blocks. It is also possible to make stabilised earth blocks from clay and earth with 10% cement. Adobe blocks are made from garden soil and cut grass. Experiment, but do not try building with clay until you have a lot more information about how to make the bricks, walls or blocks. Look in the reference section.



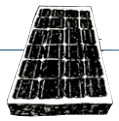
SMART IDEAS:

- A render is essential to make clay bricks last longer and to improve insulation. Use some cow manure in the render to help protect the wall from insects and the weather (and note that it does not smell when it is dry!).
- The roof of a clay house must extend out over the walls to protect them from heavy rains.



STONE

A stone house takes time to build, but if it is built well it lasts a very long time. Stone walls take a while to heat up so they stay cooler during the day. As they store heat very well, the house stays warmer at night. Another benefit is that stone is easily combined with other building materials. There is plenty of good stone in many tropical regions; the main problem is transport costs.



SMART IDEAS:

- DO NOT use the mortar to join the rocks and hold them in place. If you do, the wall will fall down in a few years. Only use it to fill in the gaps between the rocks.
- For colder areas, use the benefits of the stone but reduce the costs and time building the house by having only the west wall (sun setting side) made of rocks. This helps to keep the house cool in the afternoon and warmer at night. Planting deciduous trees next to the wall provides important shade during the hotter times of year.

Traditional stone house

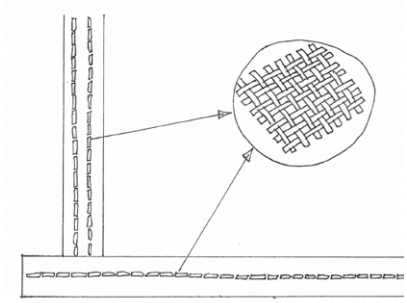
BAMBOO

Bamboo can be made into roofs, walls, outside pergolas, decorations, furniture and more. New techniques allow the use of bamboo for structural poles, and bamboo plywood and floorboards are also becoming more common.

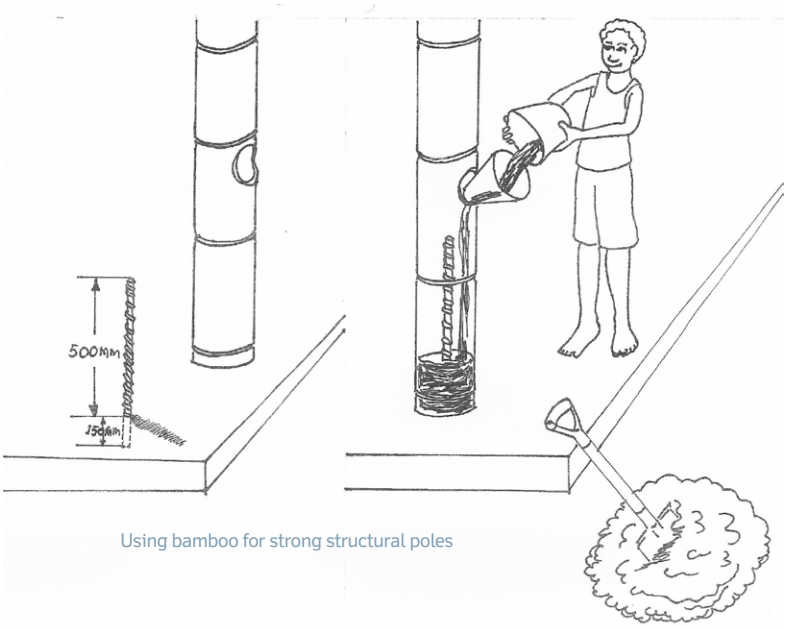
Bamboo is excellent for hot coastal areas because it gives good ventilation. It is also light but strong and easy to work with. Selecting the right type of bamboo, cutting it at the right age and curing it all make the bamboo last for many more years.

Bamboo can also be used for reinforced concrete instead of metal and is more durable in earthquakes.

Look in Bamboo (**Ch 16**) and the reference chapter for the information.



Bamboo used for reinforcing floor and wall



Using bamboo for strong structural poles

EARTHBAGS

Earthbag walls and houses are built using simple techniques and cheap materials. This method uses earth bags that are layered, then secured and protected on each side with wire mesh and render. They are longer lasting and are more durable in earthquake-prone areas. Building with earthbags needs a lot of labour so a community approach is better to get the job done quickly.

Round or curved structures are much stronger and easier to build than square structures, and they require fewer (or sometimes do not require any) supporting vertical poles.

Making the earthbags involves finding old bags or sacks, such as rice bags, or buying new bags. Some old rice bags do not work very well as they do not breathe. Be sure not to use thin bags or bags that may decompose quickly. A good option is to try to find whole rolls of double woven polypropylene material at large wholesale shops, which is used for making small bags. You can cut up the rolls and sew the material into any size bag you need. This makes construction much quicker and easier.

Fill the bags with –

- Poor quality earth
- Sand
- Crushed rubble

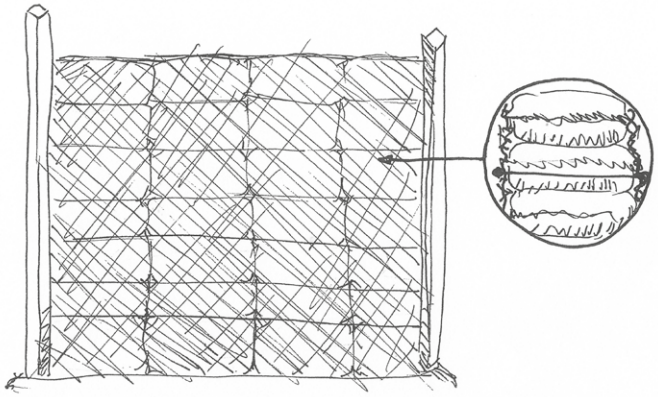
DO NOT take sand from rivers, flood plains or sensitive environmental areas.

These steps explain the basic technique but look in the reference chapter for websites with more detailed information. It is even better if you can find people in your area who have experience building with them.

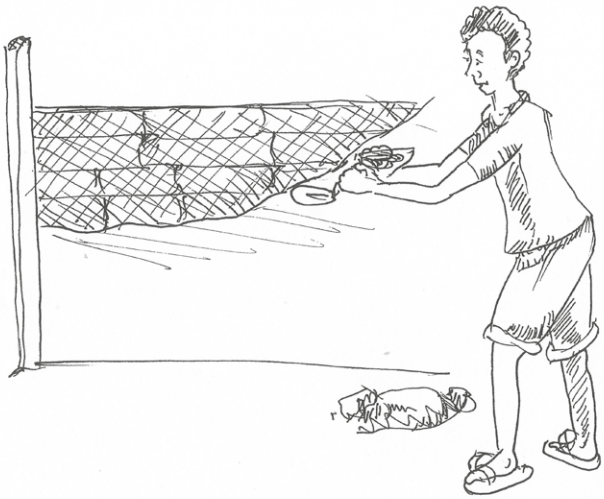
- Mark out and clear the area where you plan to build the walls.
- Prepare the base depending on what you are building and what materials you have. That could be a cement slab, cement wall base, compacted dirt base, compacted gravel base, etc. These foundations are necessary to prevent moisture rising from the ground and creating dampness and mould in the bags.
- If you use corner posts, they need to be erected at the same time as you build the foundations.
- Sew one end of the bag closed and you need to fill each bag three-quarters full with the earth/sand/rubble.
- Sew the tops closed or fold them over (but sewing is more secure).
- Lay the sacks in place and stamp them down with a heavy wooden mallet or something similar. Do that for each row.
- After the third row is complete, start to attach the wire mesh. Secure it to the corner posts and to the bags, initially at the bottom. Then the mesh goes up each side of the earthbag stack. Secure the mesh in place using

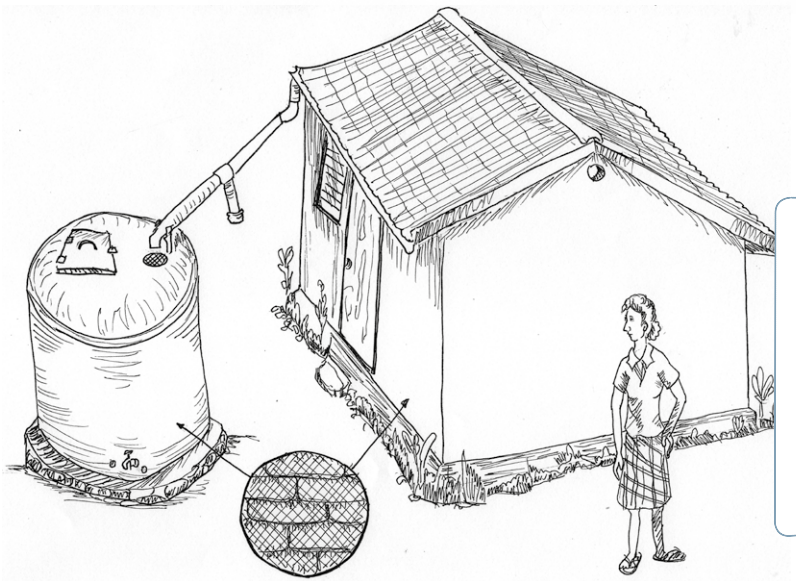
pieces of wire cut to size and pre-placed between each layer of earthbags, sticking out each side so that it can be tied to the mesh. Barbed wire can also be used. One piece of wire every 30 to 50 cm along the wall is good and vertically for every second layer of earthbags.

- Keep adding layers of bags, stamping down each layer, then securing the wire mesh as it gets higher.
- Continually check and test the wall to make sure it is straight and strong.
- Repeat the stages until the wall is at the desired height.
- Finally, secure the wire mesh on top.

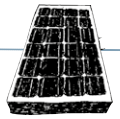


- Render the wall using the mesh to help keep the render in place. Work up from the bottom. Aim for a 3 to 4 cm thick render. Read later in this chapter for how to make render.





Earthbag house and earthbag rainwater tank



SMART IDEA:

Use bags filled with gravel or crushed stone for the bottom two layers and earth-filled bags after that. This further reduces any problems of moisture coming up from the ground.

WOOD

Wood is becoming increasing rare as a building material in the tropics because it is:

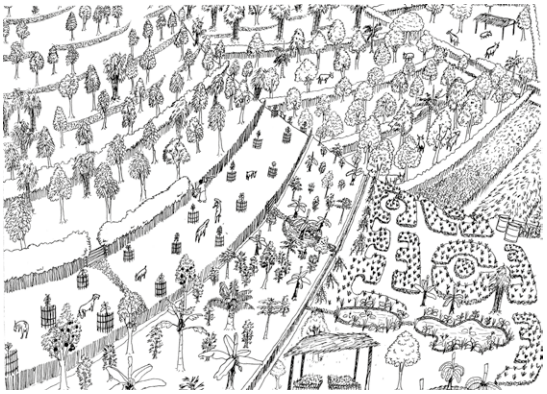
- Too expensive
- Hard to maintain – difficult to protect from insects, for example
- Too scarce a resource, especially with large-scale illegal logging destroying forests

Hardwood poles are good for the main house frame because they are long lasting. It is very important to choose hardwood from trees that are locally common, not endangered, and from plantations or recycled posts, not from natural forests. Each region has its own hardwoods. Here are some examples, thanks to the *Ecoinvent Report No. 21*, "Part 1: Life Cycle Inventory of Tropical Wood", 2007 [www.ecoinvent.org]:

- Africa: Iroko (African teak), Afara (Korina), Sapelli, Utile, Ayan, Ebony, Sipo, Okoumè (Gaboon), Moabi, Ayous, African mahogany (Khaya), Wengwe, Ozingo
- Asia: Ironwood, Amboyna, Kapur, Sepetir, White seraya, Jelutong, Ramin, Meranti varieties, Teak, Eucalyptus
- Latin America: Mahogany, Virola, Balsa, Greenheart, Crabwood, Mora, Ekki, Brazil Nut

SMART IDEA:

Plant hardwood trees for the future and grow more than you will use. They are valuable and will provide you with an income.

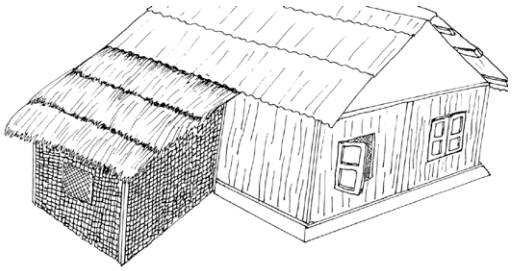


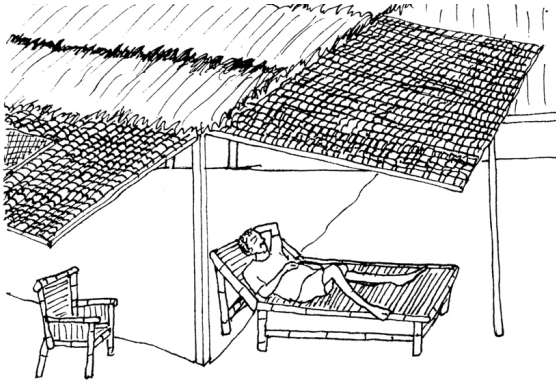
Agroforestry provides valuable hardwood timber as part of an integrated land management system

MIXED MATERIAL DESIGN

A mixed-material design means building a house using different building materials, such as stone, wood and palm-leaf stalk panels, or clay and bamboo, etc. Choose the combination best for you. Houses that are made from a mixture of materials can maximise the benefits of each material and therefore increase comfort and health.

- Clay and rock are the best materials for staying cool during the day and warm at night. Cement block walls do not work so well but improve if they are covered with render. If you use cement blocks, fill them with sand or clay to improve their ability to block out the heat.
- Bamboo and palm-leaf stalk panels give good ventilation and are cheap.
- Long-lasting insect resistant woods can form the structure.
- A tin roof lasts longer and is better for catching water. A grass roof is cheaper and is much better for insulation. A bamboo roof is another option.
- Formwork walls are another option: a mix of 8% cement with 92% clay. Build them 20 to 30 cm thick, approximately 1 m in height and up to 3 m long.





Raisable walls for increased ventilation during the day

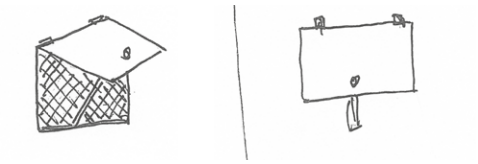
House improvement techniques

These ideas can be used for new houses or to improve existing houses. Simple, cheap improvements make a big difference to the living area as well as saving money and improving household health.

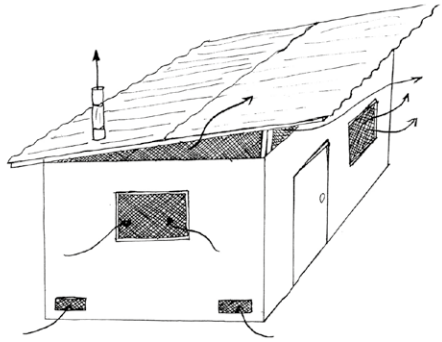
Ventilation

Good ventilation keeps a house much cooler. As hot air naturally rises, air vents help hot air to move upwards and escape. An air vent is a small hole, approximately 30 cm x 15 cm, covered with strong insect screen to stop mosquitoes, mice and rats. Placing air vents near the ground and near the roof helps air circulate through the house. As the hot air leaves through the roof air vents, cool air is pulled through the vents at ground level. **This is called convection.** You need air vents in both positions for convection to work, especially in tin-roof houses. Open windows also help to cool the house, but you need to have insect screens to keep out mosquitoes.

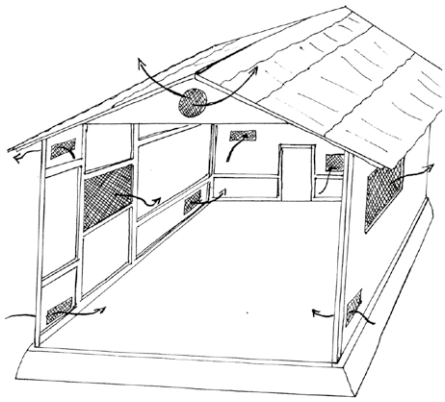
For mountainous areas, close the top vents near the roof at night to prevent heat from escaping.



Trees and plants around the house release moisture through the leaves which cools the air entering the house.



Convection for a kitchen

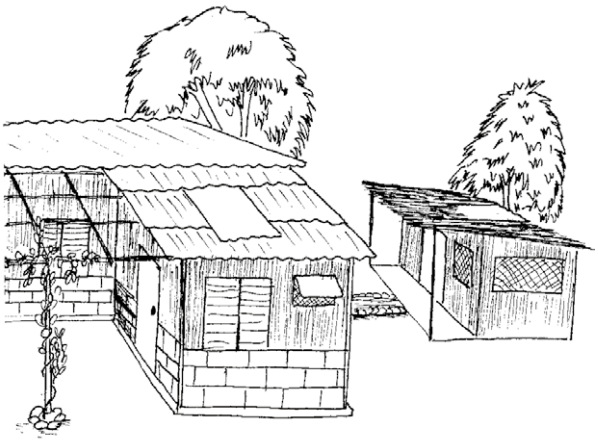


Convection for a house

Protection from insect and weather damage

Good design and a few simple techniques can make your house last many years longer and save a lot of work and money in the long term. This includes protection from rain, ground water and insects such as borers and termites.

A mixed-material design helps to protect your house from insects, mould and rot. A layer of wall at the bottom, 40 cm to 100 cm high, of cement blocks, earthbags or stone with a render provides protection. The walls above can be made from lighter materials, such as bamboo panels or palm-leaf stalk panels, to provide ventilation. This design is good for earthquake-prone regions too.



BAMBOO

Read Bamboo (**Ch 16**) for how to choose, cure and store the bamboo properly to prevent insect damage and improve weather resistance.

WOOD

- Paint sump oil (old car or truck oil), especially around the base of the pole. It helps protect it from termites and borers for much longer. Repaint the poles every two years to continue the protection. Note, however, that it does increase the fire risk for the house.
- Paint also helps to protect the poles. It looks better than oil but does not work as well.
- Use poles from trees that have hard wood and are naturally insect resistant. Traditional ceremonial houses are built using woods that naturally last for many years. This knowledge can be transferred to houses and these types of trees need to be planted for the future.

Cement post holders help stop termites and white ants from eating the base of the wood or bamboo poles, because the wood is no longer in direct contact with the ground.

STEP 1: Dig a hole in the ground, the normal depth for a house pole.

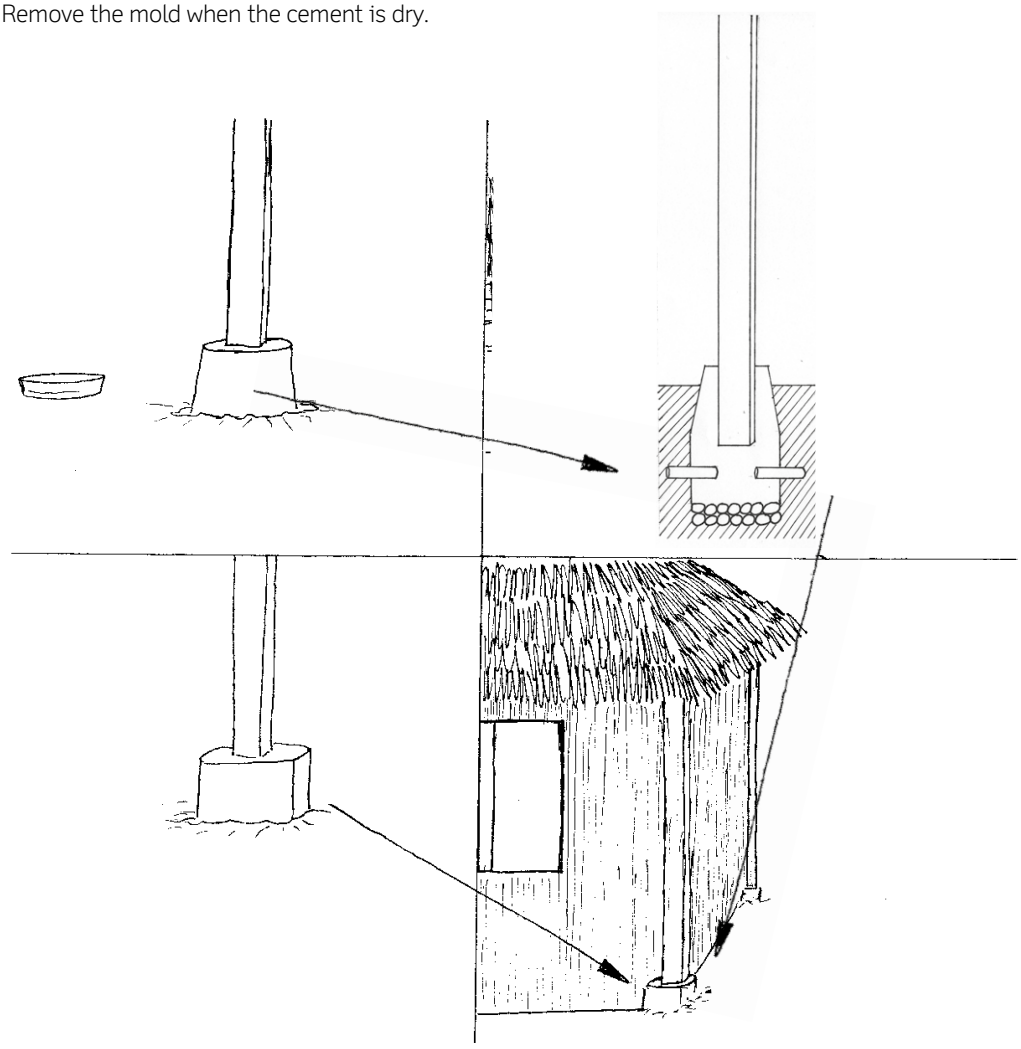
STEP 2: Prepare an old bucket or oil container to use as a cement mold.

STEP 3: In the hole, hit two metal rods or bolts horizontally into the soil about 5 cm from the bottom so the rods/bolts are half in the soil and half sticking out into the hole. This may not be possible if the ground is too rocky.

STEP 4: Fill 50% of the hole with cement, place the pole in the hole and fill it until the cement is 10 cm from the top.

STEP 5: Place a bucket or oil container mold in the hole, around the pole. Fill it with cement to the top.

STEP 6: Remove the mold when the cement is dry.



DRY GROUND

Keep the area and ground around the house as dry as possible. Wet ground around the posts and house brings white ants. They cannot live in dry ground. Wet ground also encourages mould and fungus to grow on the walls, which is neither good for the walls nor for peoples' health. Use wide roofs to prevent rain collecting next to walls and good drainage trenches to move water away from the house.

RENDER

A render covers and protects the walls, keeping the walls cooler during the day and warmer at night. Render can be used on earthbags, cement blocks, clay, rock and even bamboo and palm-leaf stalk walls.

For earthbags, clay, cement blocks, and rock, a thicker render provides better insulation and a much longer life for the wall.

Two recipes for a cheap render are:

- 8 parts sand
- 1 part cement
- 3 parts fermented cow manure (cow manure is fermented when fresh cow manure is put in a bucket with water then left to sit for 5 to 7 days.)

Or

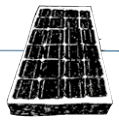
- 1 part clay
- 4 parts sand
- 5 parts fresh cow manure
- pre-soaked hydrated lime

Or

- 3 parts sand
- 1 part pre-soaked hydrated lime (for hydrated lime to work best it needs to be left in water for at least a month – the longer the better.)

The cow manure helps to seal to the render and protect it from insects. Note that it does not smell when it is dry! The lime helps to protect the walls from rain and acts as an insect repellant.

Rendering a woven bamboo panel wall



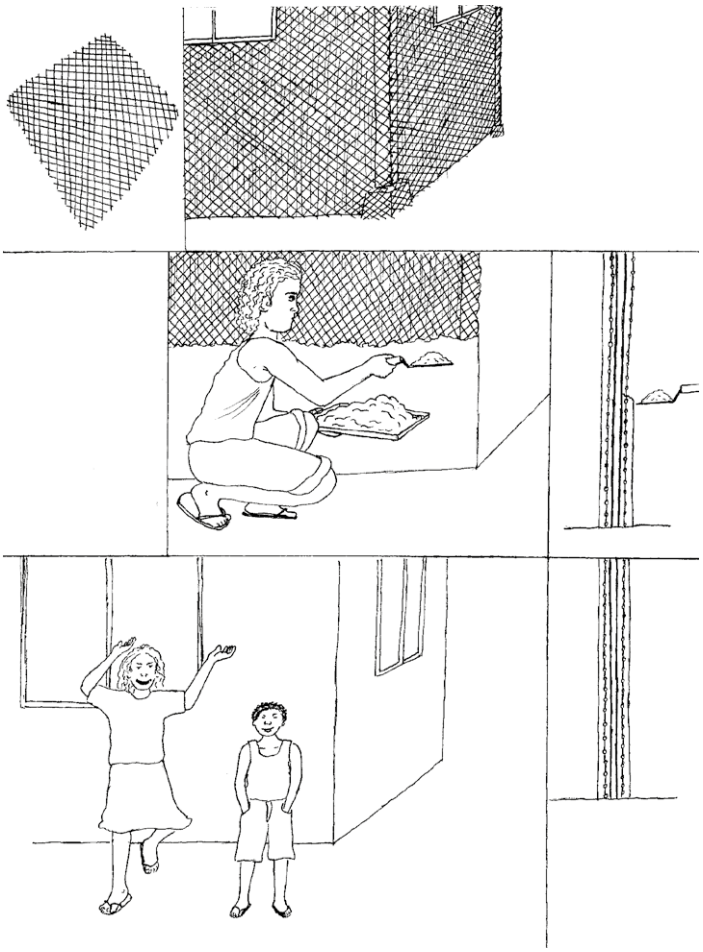
SMART IDEA:

Dirt from empty abandoned termite mounds is great to mix with render for houses. It deters termites because they connect the smell with an abandoned termite nest.

RENDER FOR BAMBOO AND PALM-LEAF STALK PANELS

This idea is best used in cooler areas.

- Cover the split bamboo or palm-leaf stalk panels outside and inside with either wire mesh or loosely woven split bamboo panels with 3 to 5 cm spacing between each bamboo strip. This holds the render in place. Rendering on both sides helps protect the bamboo or palm-leaf stalk panels from insects and it lasts much longer. It also improves the insulation.
- Apply the render until the surface is covered and you cannot see ANY of the wire mesh, bamboo or palm-leaf stalk panels. Add a second layer of render later to lengthen its life, especially in areas of high rainfall.



Rendering palm-leaf stalk panels

ROOFS

- Smoke from a wood fire helps a grass roof last longer because it deters insects and helps make it waterproof. However, if you have a fire burning inside all the time, more and more smoke stays inside over time as the roof becomes more sealed. Therefore, you need to provide a chimney or an outlet for the smoke to escape to prevent health problems caused by too much smoke.
- Roofing nails are much better to anchor roofs than normal nails. They hold the roof down in strong winds and make it last longer.

Insulation

Insulation keeps the house cooler during the day and warmer at night. Thick walls made from rocks, clay or earthbags provide good insulation in mountainous regions. Render, described earlier (as it helps to prevent insects and weather damage), also provides extra insulation.

ROOF INSULATION

Traditional roof materials are very good insulation. Manufactured insulation material for houses and other buildings, designed to fit under roofs, is available in bigger towns and cities. The insulation keeps the buildings cooler in the heat and warmer at night in cold areas. It is expensive but for houses and businesses it makes a big difference to comfort and saves money that would be spent on electricity to run air conditioners and fans. Coconut husks would make a great insulation material too.

CAREFUL: Insulation can become a home for mice and rats. If you use insulation make sure they cannot access it.

CURTAINS

In cold areas, curtains or material that covers the windows on the inside stops some heat escaping at night. In hot areas curtains on the western side reduce the amount of heat that enters the house.

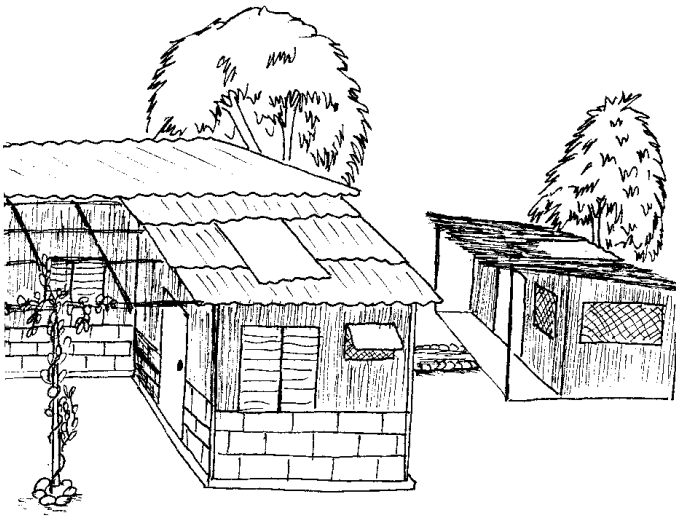
Natural light

It is important to provide natural light in houses as it is good for wellbeing and reduces the use of electricity and other methods of artificial lighting. Some types of traditional houses can be quite dark inside, so including large windows in the house design allows in natural light. If glass is too expensive or not available, cover the open windows with insect screens to stop mosquitoes and animals from entering.

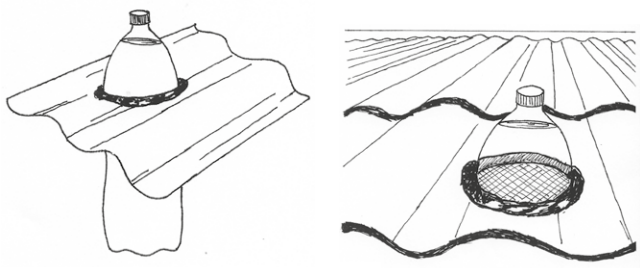
SKY LIGHTS

For rooms with only a roof and no interior ceiling a sky light can increase the amount of natural light. There are two easy methods:

Fit a piece of clear plastic sheeting, the same size and shape as tin roof sheets, in the roof.



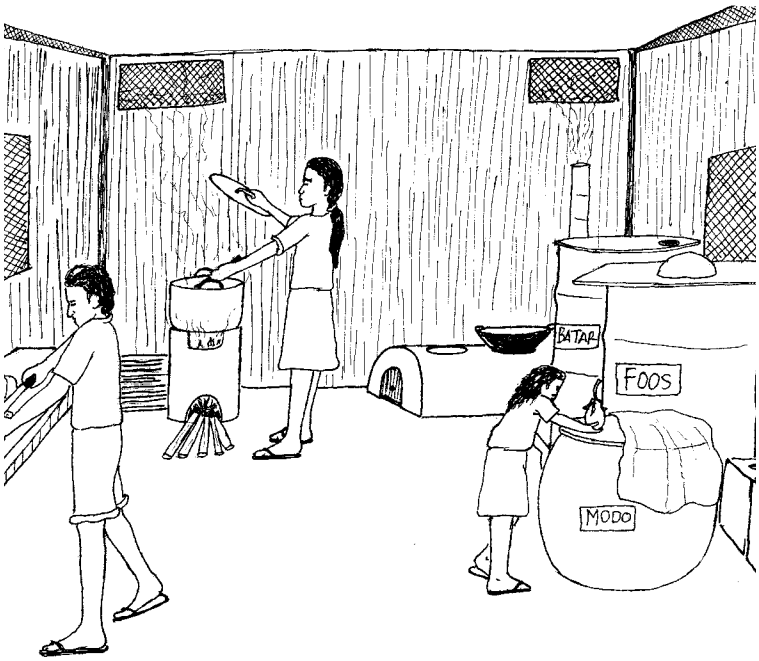
Plastic bottle light is a recent development using very simple technology by Illac Diaz of MyShelter Foundation (see the reference chapter for details). It is a plastic bottle filled with water that when inserted into a roof can produce as much light as a light bulb!



1. Prepare a square of tin roofing about 30 cm by 30 cm. Cut a hole in it slightly smaller than the water bottle. Then from the middle cut slits in the tin at 1 cm intervals and about 1 cm long. This creates tabs that can be folded upwards until vertical. Insert the plastic bottle so that the metal sits near the top of the bottle and the tabs, pointing up, hold the bottle in place.
2. Secure the bottle in place with a silicon sealant. This also stops any leaks. Fill the bottle almost to the top with water and a cap of chlorine. The chlorine keeps the water clear. This is important but be VERY careful handling the chlorine, as even a small amount is poisonous.
3. Cut a hole in the roof tin where you want the light to go, the same size as the bottle. It is very important to line up the square of roofing attached to the bottle with where you make the hole. The corrugations in the tin must match and fit together. Fit the bottle in place with the square of tin sitting on the roof. Use the silicon sealant to secure the tin square to the roof and prevent leaks.
4. You now have sunlight in a bottle!

Insect screens

Mosquitoes cause many diseases. Covering all windows, vents and openings with insect screens stops the mosquitoes entering the house and reduces disease. Mosquito nets over beds prevent mosquitoes biting people while they sleep.



Insect screens on windows and air vents in a kitchen

Outside improvements

In tropical regions people spend a lot of time outside the house. Creating a good outdoor living space improves your house a lot by:

- Expanding the house area
- Creating a more livable, beautiful house
- Making use of the micro-climates created by the house
- Reducing the heat inside the house
- Increasing the production of foods for cooking such as herbs, spices, greens and salads

SMART IDEA:

Make the most of your space, but remember to think about what it will be like in 5, 10 and 20 years. A tree planted in the wrong spot might not be a problem immediately but it will be later on. Also, too many large plants might actually limit cool breezes and sunlight. Finding a good balance is important.

Creating and using micro-climates

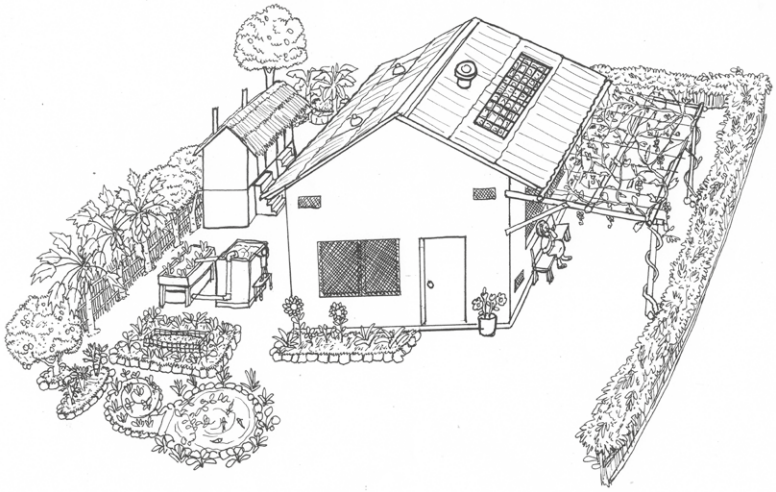
THE HOUSE

Your house can be a creator of micro-climates. There are areas that stay warmer, areas that are more wind protected and areas that are shadier. These areas should be recognised, used and enhanced to develop the micro-climates. Two examples are to create a space protected from strong winds and in mountainous tropical areas a space that stays warmer as night. The results are that outdoor living areas are more comfortable, plants in the area produce more and you can grow plants that otherwise cannot grow in your area.

For new houses, a good design includes the potential outdoor micro-climates, creating special areas.

For existing houses, an inclusive design identifies the micro-climate areas to be enhanced by, for example, adding an extra wall, fencing/trellising, a pond or a pergola/shaded area.

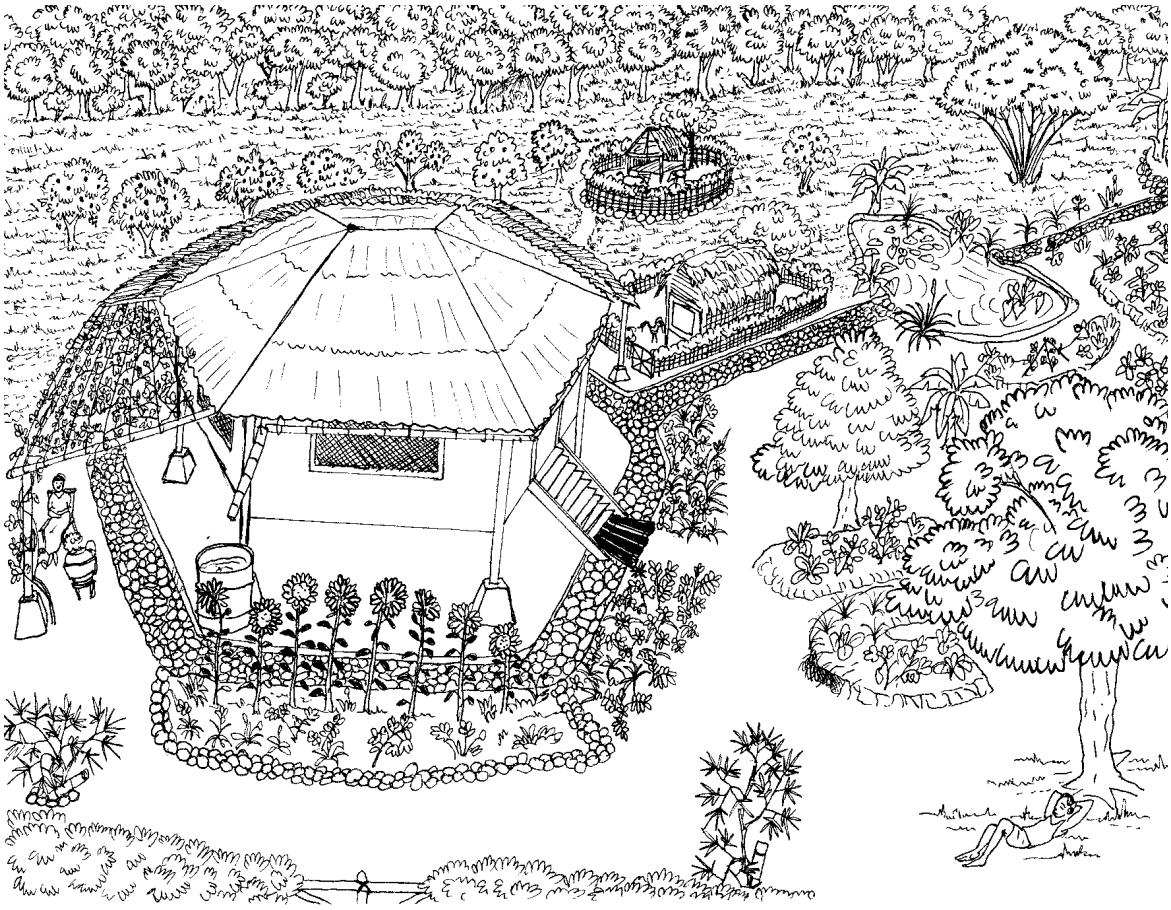
Before improvements



Making and using micro-climates to make the house more comfortable and add food production around the house

PERGOLA / SHADE STRUCTURES

A pergola or shade structure can be large or small. They are simple to make and provide a shaded outside living area. They also keep the house cooler by growing many different vines over the pergola, including passionfruit and grapes. You can place palm leaves to cover the structure and provide shade until the vines grow over it. Pergolas can also shade a small nursery.



A house with pergolas, gardens and good water management around the house

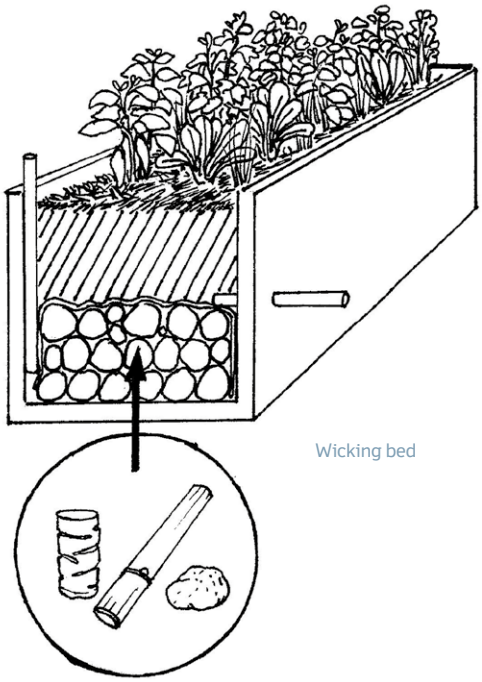
GARDENS

Gardens around the house make the house area more beautiful. Flowers, vegetables, herbs and medicines can all grow together. As leaves hold moisture, the trees and plants help to keep the air cooler. Be careful not to put gardens directly against wooden posts or walls or you will encourage rotting and insect problems. Grow food that you want to pick fresh every day and read the "what to grow around the house" section in Food, Health and Nutrition (Ch 8)

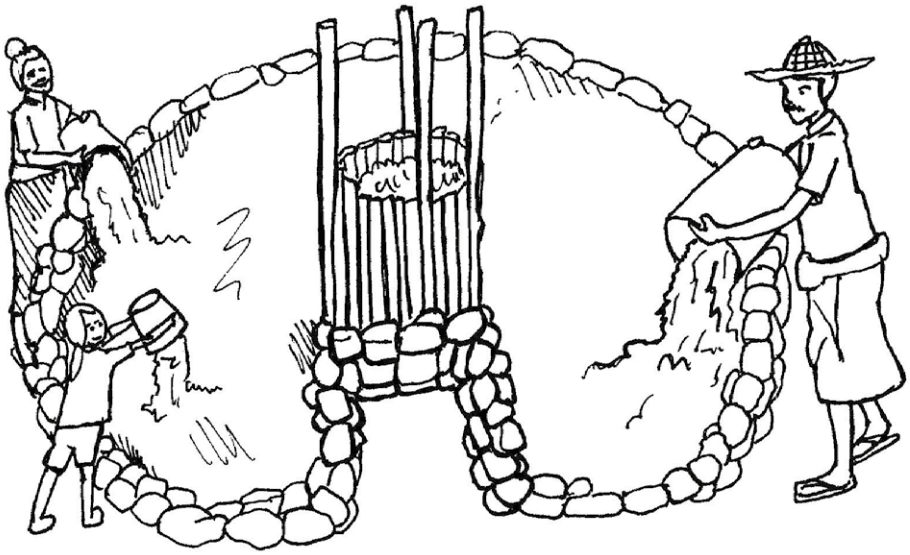
Some garden designs and techniques are best suited for near the house, and for maximising production and water efficiency in small spaces.

Examples:

- Spiral gardens **Ch 10**
- Wicking beds **Ch 10**
- African keyhole beds **Ch 10**
- Worm farms **Ch 9**



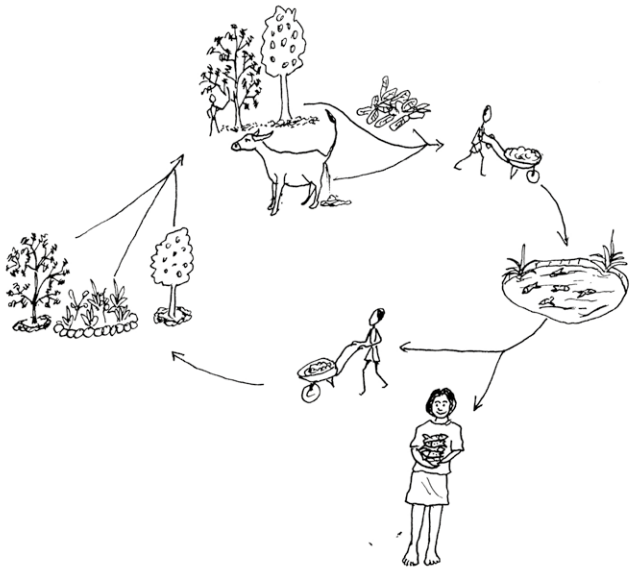
Wicking bed



Making an African keyhole bed

PONDS

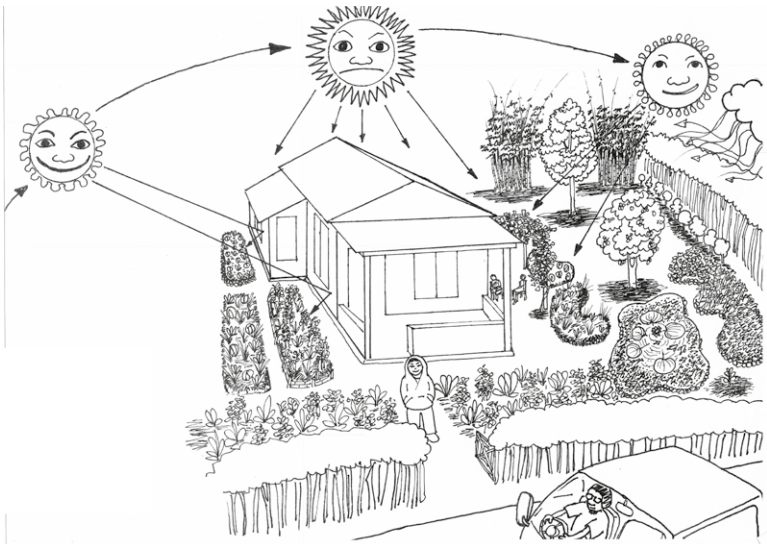
A pond adds beauty to the house area and provides you with fish and vegetables. A large pond keeps temperatures cooler during the day and warmer at night. This is because water is slower than land to increase in temperature during the day and slower to cool down at night. Add a few mosquito larvae-eating fish, such as Tilapia and Gourami, or add neem leaves and seeds regularly to prevent mosquitoes from breeding.



TREES AND WINDBREAKS

Trees provide shade for the house, keeping it cooler and, if grown together as a windbreak, they protect the house from strong winds. Trees also help to keep the air and wind cooler because of the moisture in their leaves.

Be careful because too much vegetation reduces cool breezes and increases mosquito populations.



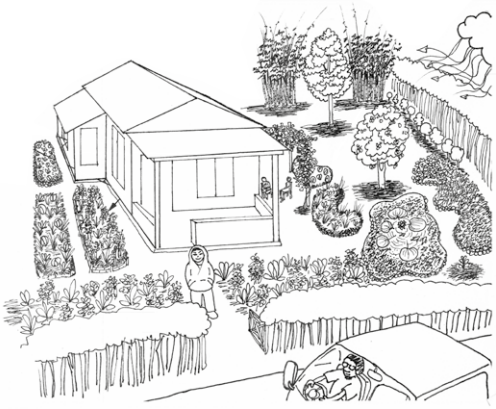
SMART IDEAS:

- In hot coastal areas, build a pergola/shade structure or plant trees or vines on the western side of the house (where the sun sets). This helps to keep the house cooler at nights.
- Some trees, such as large fig trees, grow far too big to be planted next to a house. Too much shade can cause moisture and ventilation problems in the house, and other plants do not grow well. Also, the roots lift floors and footings and crack walls when the tree gets older.

GROUND COVERS AND DUST PROTECTION

Dust is more than just an irritation. It contributes to blocked noses, sinus problems, and asthma and breathing difficulties. It is common in all tropical countries but especially in the dry tropics. Solutions include:

- Grow tough ground cover plants. Choose grasses and plants that tolerate being walked on and can grow with little or no water during the dry season.
- Plant vegetation screens. They are very useful, especially for houses next to dusty roads. Do not grow edible plants because they collect lots of dust and can become wind stressed, but they can provide other products.
- Put up palm-stalk screens.
- Protect the plants from goats!

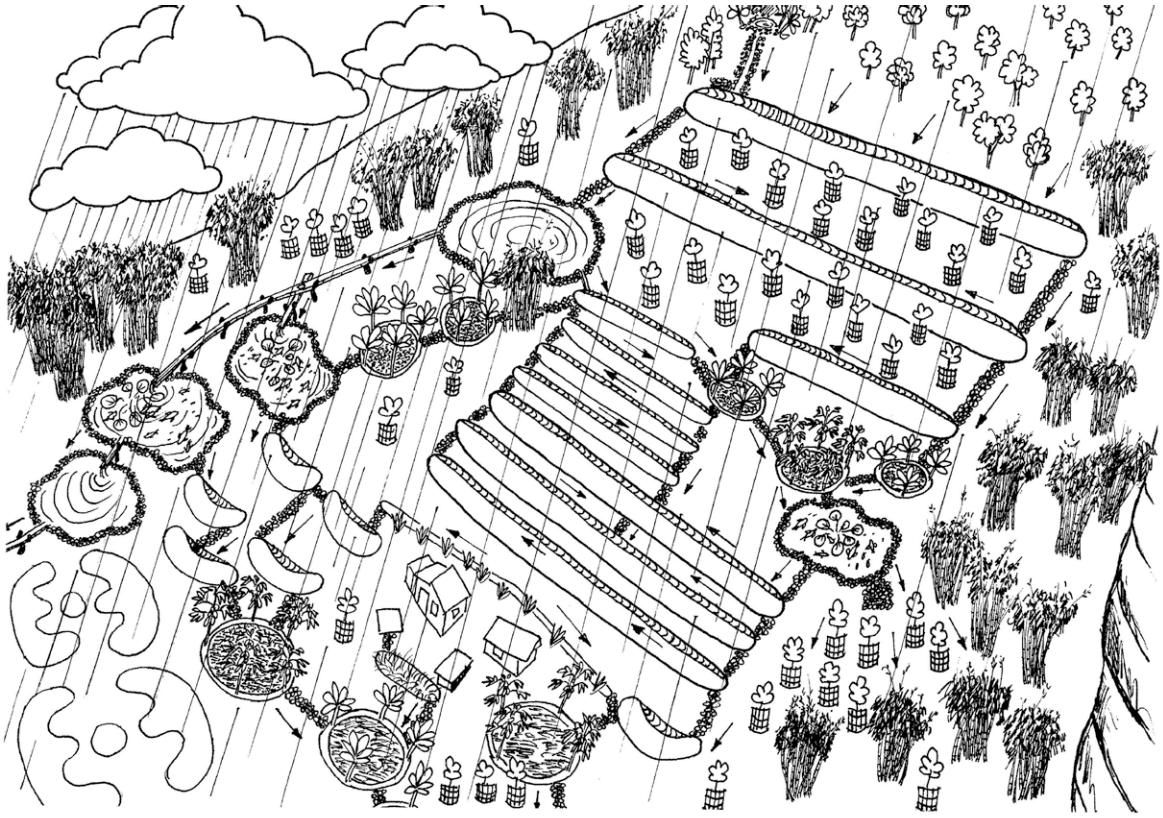


Living fence screen next to road to reduce dust

WATER FLOW

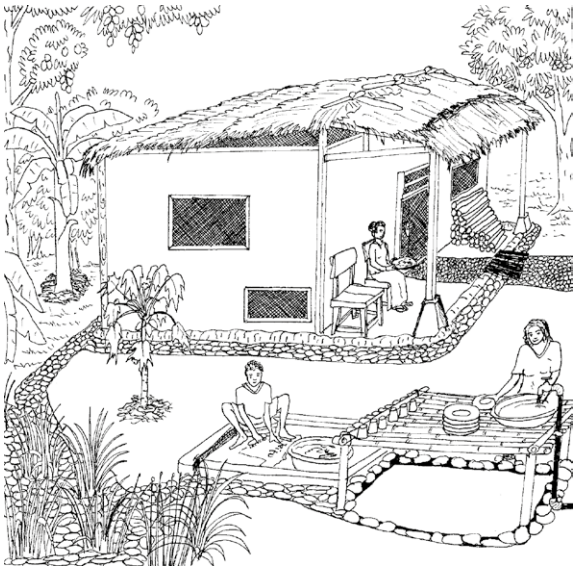
As explained already in this chapter, rainwater can collect and be a big problem around the house OR it can be caught, moved and used as you need it. Good designs turn problems into many benefits:

- Prevent minor flooding using trenches and water channels above the house to move water away towards where you want it to go.
- Catch and store water from the roof.
- Move excess rainwater from roofs and the ground away from the house and into compost/banana pits, ponds, swales and other water catchments.
- Prevent water from becoming a breeding area for mosquitoes.
- Clean and reuse all wastewater from the kitchen and bathroom (read the cleaning wastewater section in this chapter).



Kitchens

Many people spend more waking time in the kitchen than in any other room in the house, especially women. Therefore, it is very important that it is a healthy, clean environment.

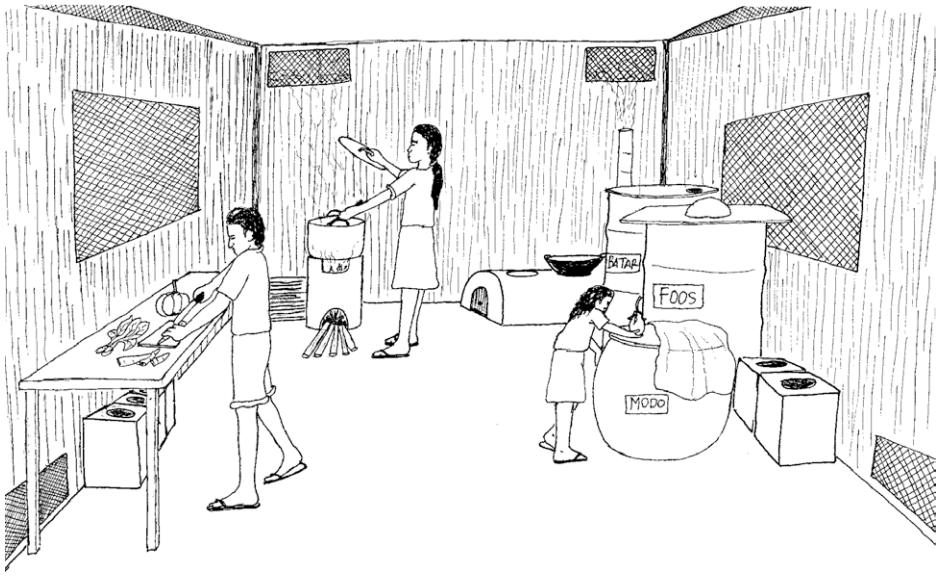


The kitchen includes the washing area.

A well designed and built kitchen has:

- Excellent ventilation to remove smoke, heat and odours
- Lots of light for preparing and cooking food
- A floor designed for easy cleaning
- Water run-off trenches outside the kitchen that clean and reuse all the wastewater, as well as preventing mosquitoes breeding
- A stove and/or oven that reduces the amount of wood used and smoke produced
- An organised, accessible food preparation area that makes cooking as easy as possible
- A verandah, shaded area or pergola to cool the kitchen and provide an outside preparation area
- Good sanitation and hygiene
- Good food storage
- Firewood/cooking fuel storage place – wet or green wood produces A LOT more smoke
- No animals

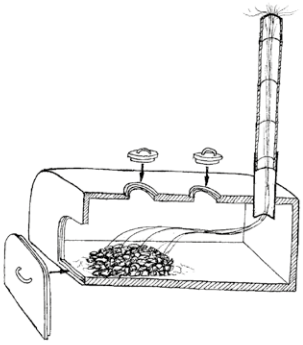
An unhealthy kitchen is dark, smoky and hard to keep clean with water lying in puddles outside and animals inside. This causes serious health problems for the family and spreads diseases. Women must be included in the designing process because they generally understand and use the kitchen a lot more than men.



Kitchen improvements

STOVES AND OVENS

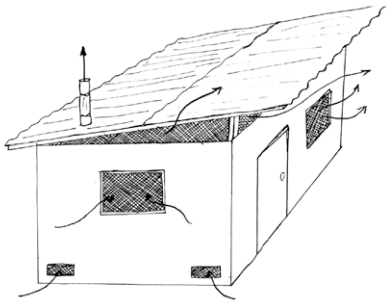
Stoves and ovens are essential for reducing the amount of smoke in the kitchen from cooking over an open fire. There are many different stoves and ovens including traditional types and those that use much less or no wood. Read Food, Health and Nutrition (**Ch 8**) for how to make and use stoves and ovens as well as other cooking technologies.



Cross section of cooking stove

VENTILATION

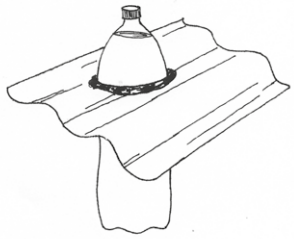
Good ventilation is essential in kitchens to reduce the smoke. Smoke in kitchens significantly increases the risk of tuberculosis, and many other health problems. Using plastic to start fires is a big problem in poorly ventilated kitchens because the smoke from plastic is very poisonous. Good ventilation is also important when the cooking fuel is kerosene or gas.



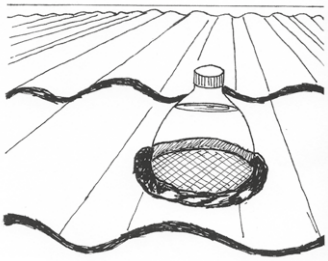
- Air vents low down and high up on the walls allow air to flow. Air vents are small holes (approximately 30 cm x 15 cm) covered with insect screen to stop animals and insects.
- Open the windows.
- A gap between the walls and roof allows smoke to escape. Cover the gap with insect screen to reduce mosquitoes.
- A chimney lets the smoke quickly leave the room.

LOTS OF LIGHT

Kitchens are often very dark. This makes preparing food difficult and could lead to accidents in the kitchen. Solutions include:



- Use combined vents for ventilation and light.
- Have an outdoor area or separate food preparation room.
- Insert sky lights – clear plastic roof panel or the plastic bottle light (as above).
- Put in windows.
- Windows and air vents need screens to:
- Stop animals from entering, especially rats and mice.
- Reduce the number of mosquitoes.



Kitchen health and management

A good kitchen should be easy to use and keep clean, and not too hot. This improves family health, reduces hard work and makes life more enjoyable.

SANITATION

Many diseases begin and spread in unhealthy kitchens and washing areas. If the area is hygienic and easy to clean, many diseases are prevented. It means that a good kitchen design involves the easy maintenance of sanitation, not that the area should be cleaned more often. Vinegar and lime juice are both good natural cleaners. Add some to the water used to clean the food preparation area and floor to kill some of the bacteria that causes sickness.

Making kitchen cleaner from vinegar and citrus peel (See Ch 8)

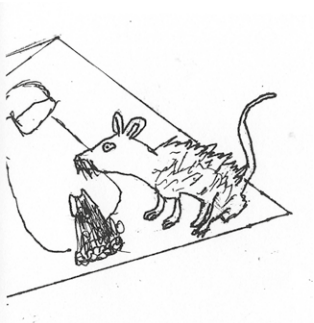
FOOD PREPARATION AREAS

It is best if the food preparation area is off the ground, at about waist height.

- This keeps animals away from the food.
- It is easier to keep clean.
- There is less bending over, which causes back problems and makes food preparation much harder.

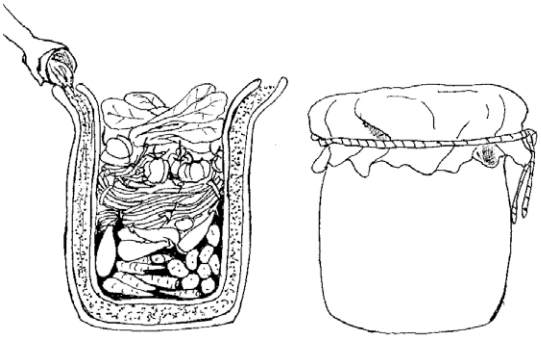
FOOD STORAGE

Store food in bags or containers that animals and insects cannot reach: for example drums for rice and corn, old biscuit tins, plastic containers, etc. Hang food bags from the ceiling and use a circular lid along the bag tie to stop rodents climbing down from the roof.



A rat eating badly stored food

Good food storage



Storing fresh food in clay pots

FLOORS

The floor of the kitchen is easier to keep swept and washed if it is slightly higher than the level of the ground outside. A floor made from rocks with mortar or cement render is much better for health, and easy to wash and sweep. A slightly sloped floor enables water to drain away after washing.

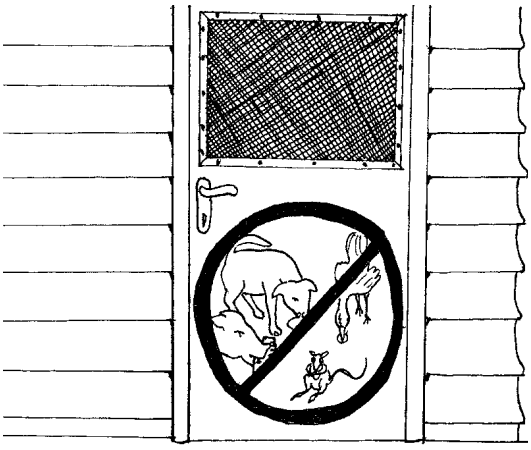
ANIMALS

No animals should enter the kitchen.

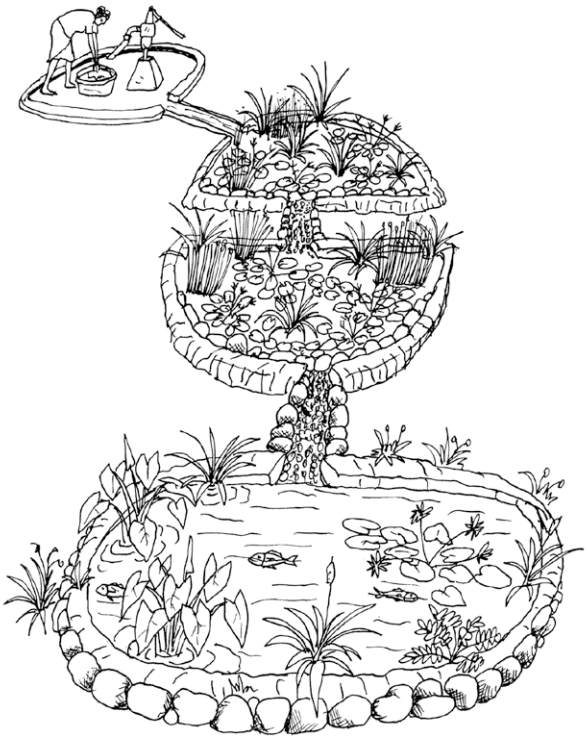
Put all the food scraps in a bucket or container and feed them to the animals away from the kitchen area.

Chickens, dogs, cats and pigs all carry bacteria that can make people sick. There is more chance that they will spread disease to humans if animals are in the kitchen. Chickens are very likely to defecate in the kitchen, which is not healthy or nice to smell!

Many kitchens do not have doors, allowing access to animals. A door can be just a simple frame of wood with an insect screen. **It costs a little money, but it is worth it because it improves people's health.**



A half door to stop dogs, pigs and chickens is good, but a proper door also prevents rats, mice and mosquitoes from entering.



WASHING AREAS

It is healthier and easier to have the washing area off the ground. A small table made of split bamboo for the dishes to dry in the air is a good, hygienic option. Dish cloths get dirty easily and spread bacteria from dish to dish.

Many people wash clothes in the rivers because their houses have no running water. When water does become available in villages it is important to stop washing clothes in the rivers because the pollution from the washing powders creates huge damage to river systems and poisons the fish and animals which live in and near them. It also saves time and hard work.

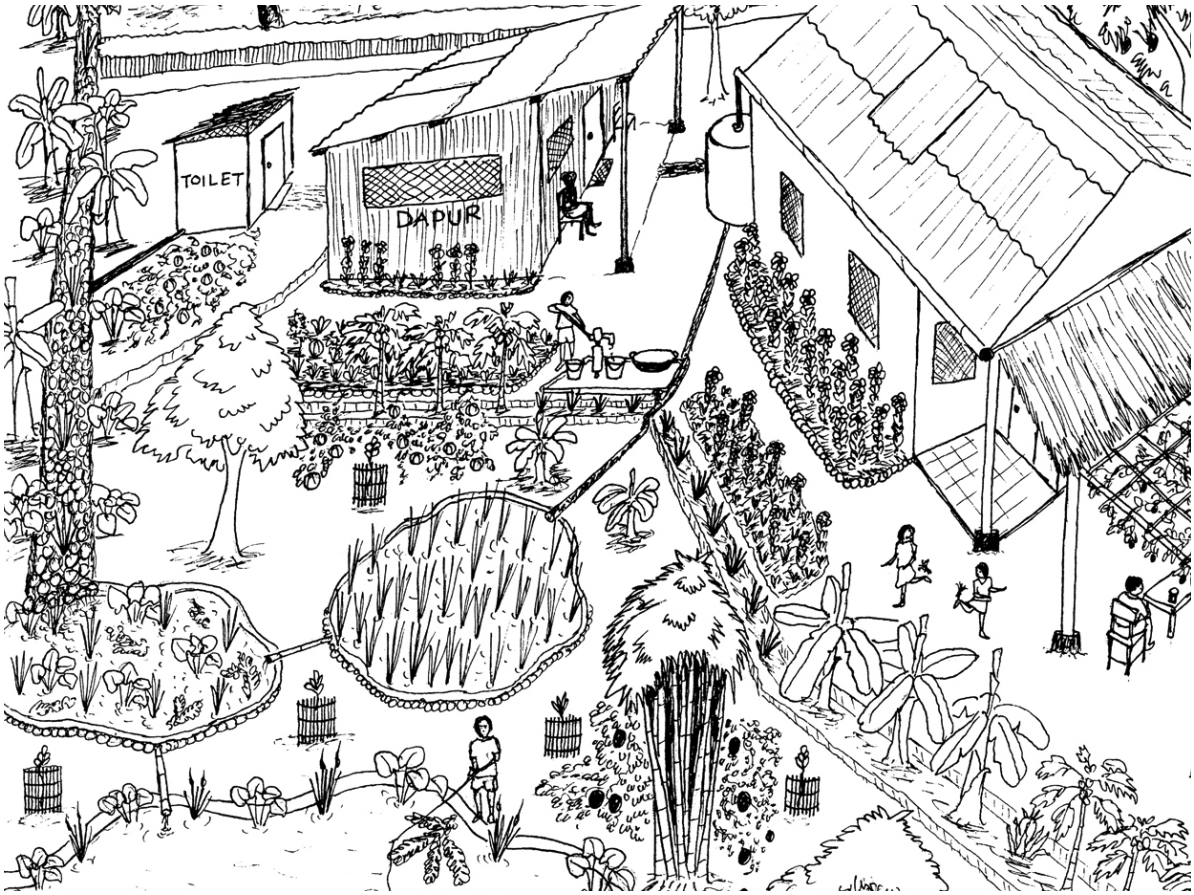
Create a combined washing area for dish washing and a washroom so the dirty water can easily be collected, cleaned and reused to grow fruit and vegetables.

Cleaning and using wastewater

The following techniques are for wastewater from the kitchen, clothes-washing and the washroom. If possible, combine the wastewater outflow to reduce work and maintenance.

Wastewater gardens not only clean and reuse water but also reduce disease risk, remove pollution and look beautiful as well.

Importantly, any water that leaves the land and enters rivers must be clean.

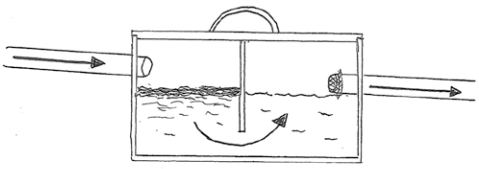


OIL TRAPS

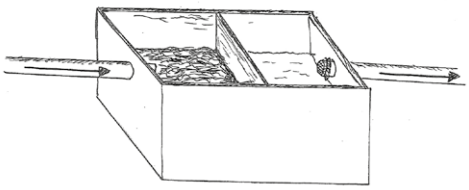
Used water from kitchens and washing dishes sometimes contains oil. Too much oil is not healthy for water-cleaning systems and it should be removed first.

An oil trap is a simple method to remove oil before it enters the cleaning system. It is a simple cement or hard plastic box with a baffle or sleeve in the middle. There is a gap between the bottom of the sleeve and the base of the oil trap. Dirty water comes in one side at the top and is forced under the gap through to the other side. As the oil layer floats on top of the water, it stays on the first side and cannot pass under the gap. The water on the second side leaves via a pipe through to the next step of water cleaning.

The oil trap needs to be cleaned every two weeks to a month depending on how much oil builds up.



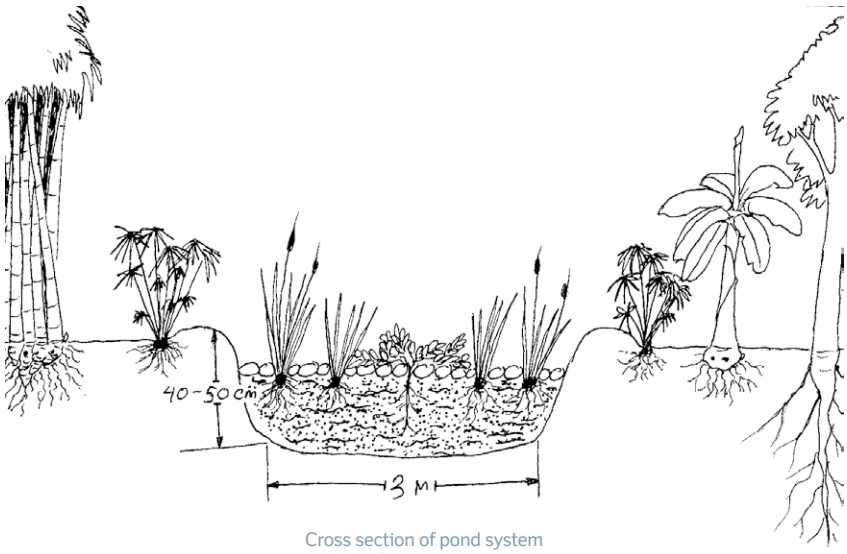
Cross section of oil trap



POND SYSTEMS

When soap and detergent enter the pond it is NOT a good environment for growing aquatic vegetables for food or fish. Reeds, bulrushes and other water plants clean the water by absorbing the chemicals and nutrients from soap and detergent and storing them in their stems and leaves.

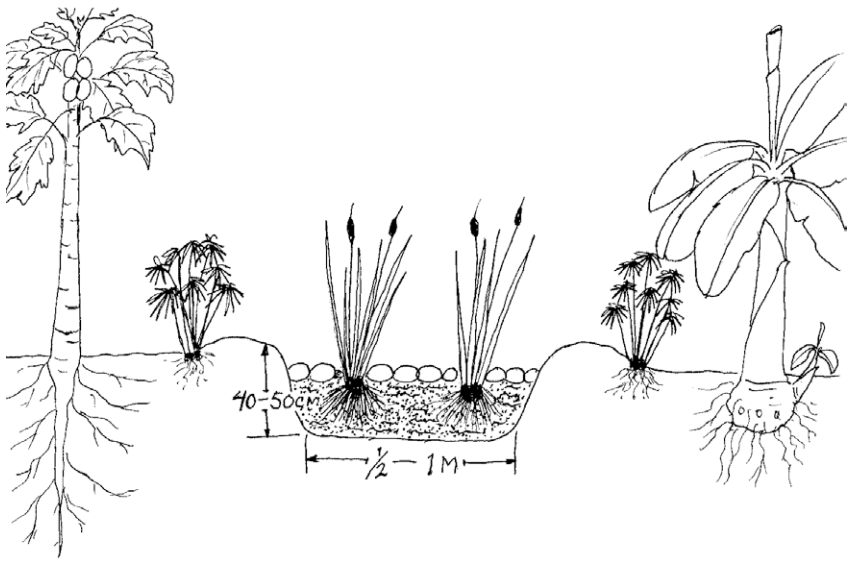
To clean the water properly the pond needs to be 3 m x 3 m or more for the use of a large family and 40 to 50 cm deep (approximately one square metre per person). Fill the pond with sand and add a thin layer of small rocks. Plant the water plants into the sand. Cut the water plants back regularly and use the material as mulch around fruit trees. The pond needs a place where the water can overflow, especially for the wet season. The overflow water can run in a trench to a banana pit or between vegetable plots. There is regular overflow only in the rainy season or in high clay locations from this system, unless clay forms a base for the pond.



Cross section of pond system

TRENCHES AND PIT SYSTEMS

The water can run through an absorption trench and into a banana pit. First, dig the trench 40 to 50 cm deep, 5 to 10 metres long and approximately 50 cm wide. Fill the trench mostly with sand and top it with a layer of small rocks. Line the edges of the trench with reeds or bulrushes to help clean the water. Any extra water that flows out of the trench runs into a banana pit or swales. Grow bananas, papayas and other small fruit trees along the side of the trench, but not too close or the bananas will spread and damage the trench.



Cross section of trench system

SLOPED LAND TRENCHES AND SWALE SYSTEMS

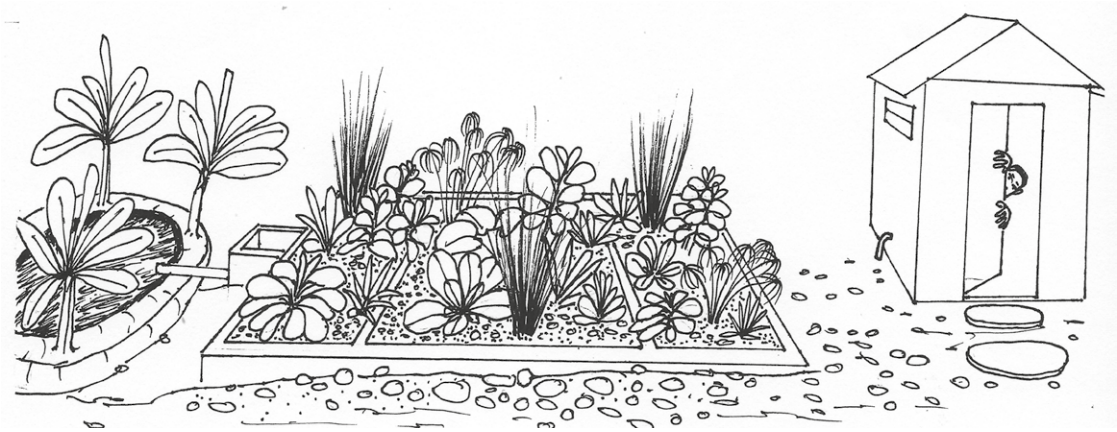
On sloping land the water can run, via a pipe or small absorption trench, down into a swale. Fill the bottom (trench) of the swale with sand and gravel. Grow reeds and bullrushes to help clean the water. Plant papayas, citrus, chillies, pineapple and more on top of and below the swale, and bananas below the swale. Do not plant vegetables, especially not root crops, such as cassava, sweet potato or yam, but pumpkins and watermelons are good.

For many regions where water is scarce, the trench or swale methods are much more practical and easy to maintain.

CEMENT WASTEWATER GARDEN (WWG) SYSTEMS

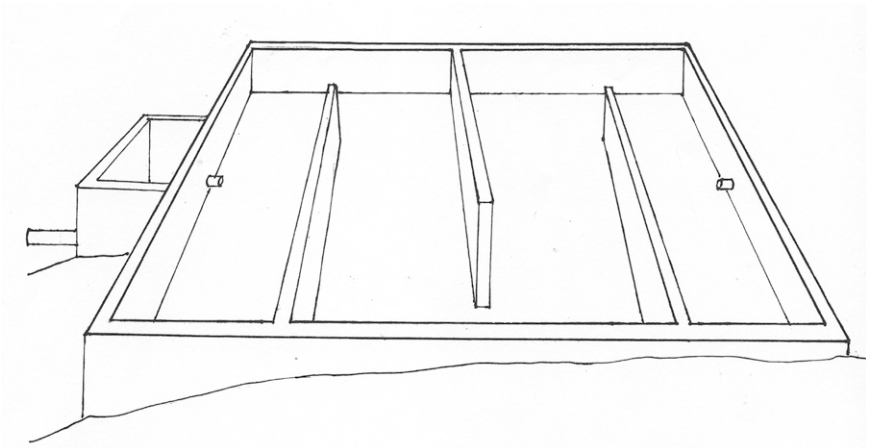
A cement wastewater garden system is great for urban areas, towns and places that use a lot of water such as hotels, restaurants, government buildings, schools, etc. They are expensive to make but they work well and are easy to maintain and regulate. They can look beautiful with a variety of flowering water plants.

Look in the reference chapter for websites that explain WWG systems in detail.



Some features of the cement WWG system:

- It is a self-contained system.
- The cement baffles in the WWG system slow the water down and make sure it passes through as much filtering as possible so it is properly cleaned.
- Its size depends on the number of people who use it and how much water is being cleaned. To clean kitchen/ wash room and clothes-washing water combined, allow approximately one square metre for each person who uses it regularly. Systems just for kitchens or washrooms can be a lot smaller.
- It needs an overflow pond or pits. Often there is no excess water but in the wet season there will be regular overflow.
- The shape depends on the land, slope and other buildings, etc.
- One big WWG system can service many houses which is great for urban and town water cleaning.



MANAGEMENT TECHNIQUES

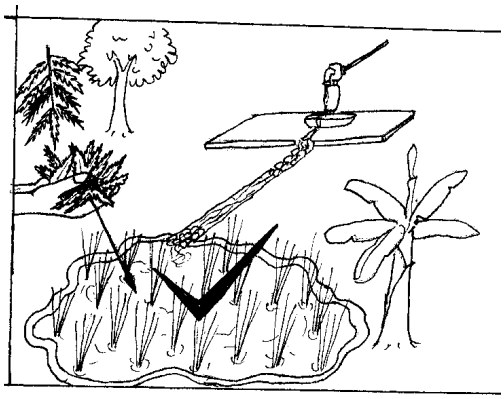
Plants to use:

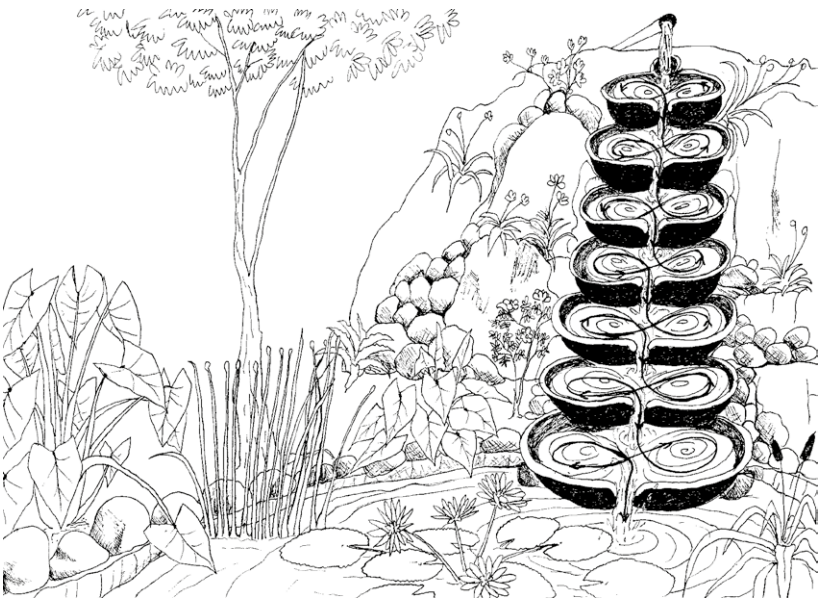
- Phragmites plants are the best water cleaners. It is a type of water reed that can grow more than two metres high. It is easy to grow – dig up some root stock, carefully divide it and replant it. It spreads rapidly through its runners which put down roots and forms extensive reed beds
- Water hyacinth is excellent as it lives on top of the water and multiplies very quickly.
- Water lilies, bulrushes papyrus, wetland ferns (*Acrostichum spp.*), elephant ears (*Aroideae spp.),* taro and *Canna spp.* also work well.
- Look for local varieties of these plants or other similar water plants to use.
- Be careful not to introduce new plants that could become a weed in an area where they are not already growing, especially water hyacinth.
- DO NOT eat the plants or feed them to animals

Removing plants: After a few years the water cleaning plants may take up all the space and need thinning. Remove two-thirds of the plants, including their roots, and add to slow compost or use as mulch. Replace the gravel and sand if needed. Bananas and other plants growing nearby also need to be regularly cut back.

Fencing: Any ponds that clean water from kitchens, washrooms or toilets need to be protected from animals, such as ducks, pigs, goats, cows and buffalo, which drink the water or eat the plants. It could make the animals sick and they could damage the water cleaning system.

Preventing mosquitoes: Place a cup of neem fruit/seeds and four cups of neem leaves in a cloth with a rock, tie it up and sink it, slowly releasing neem oil into the water. Or add 20 ml of neem oil. Repeat it every three months.





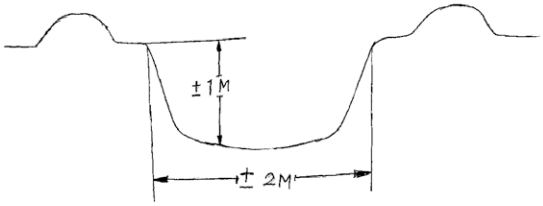
Clay flow-forms help clean water and add oxygen to it. These can be part of any water cleaning system and a potential local enterprise opportunity.

Washrooms

There are many different ways to make a washroom from very simple compost showers to rock, clay or cement block washrooms. Use whatever building materials are most appropriate for you.

The most important idea is to make use of the wastewater.

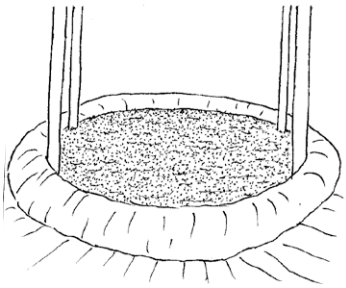
Compost showers

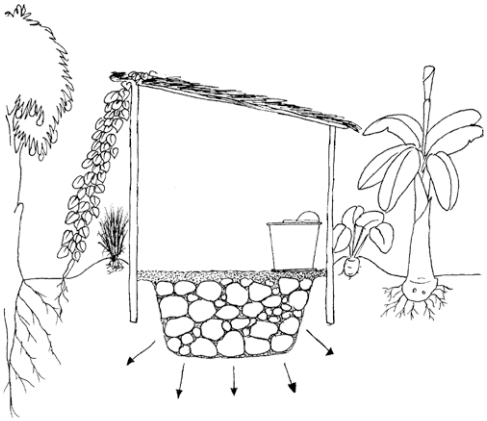


This is a cheap and simple way to directly reuse the water. A compost shower is a pit circle, dug approximately two metres diameter wide and 50 cm deep.

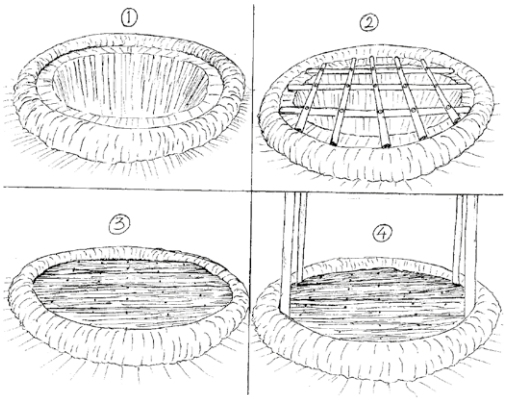
There are two methods for making the shower.

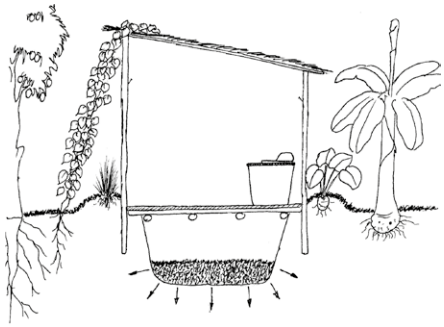
1. **Fill the hole with:**
   - A 10 cm layer of palm hair, covering the sides as well
   - Rocks or coral until they are near the top
   - Gravel for between the gaps and add a top layer of gravel 5 to 10 cm thick. This allows the water to filter through easily into the ground.



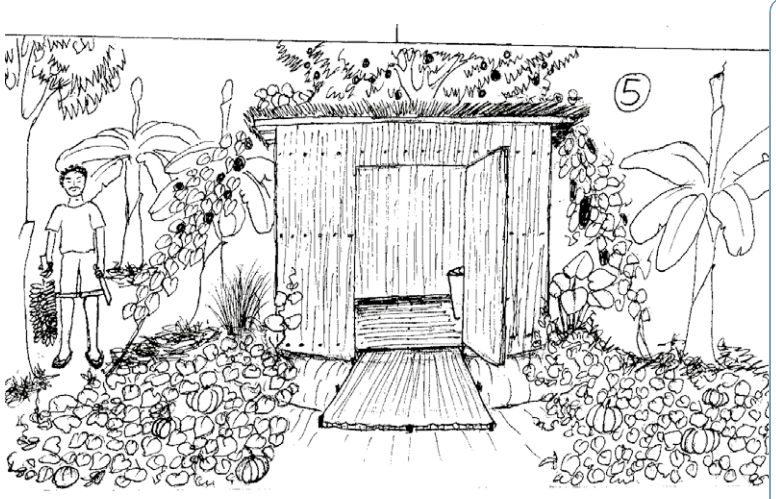


2. **Half fill the hole with coffee or rice husks.** This soaks up the water. Then make a floor with hard wood poles covered with palm-leaf stalk panels. It may be necessary to make a new floor after a couple of years as the materials are likely to rot.





Build a simple structure around the shower to give privacy and provide trellising for vines. The ground stores all the water for trees and plants to use. Around the edge grow bananas, pumpkins, gourds, luffas, watermelons, papaya trees, pineapples, chillies, tomatoes, passionfruit and other plants to benefit from the water.



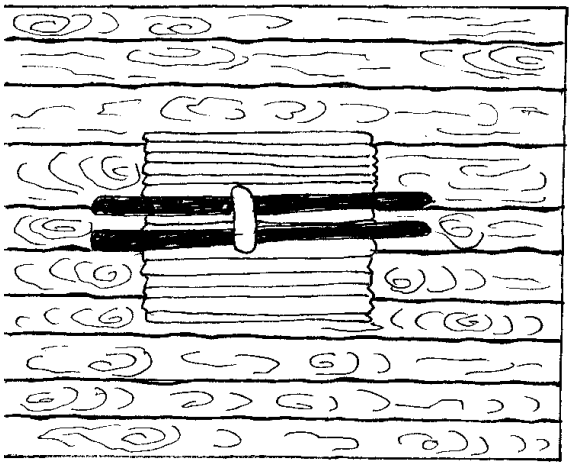
SMART IDEAS:

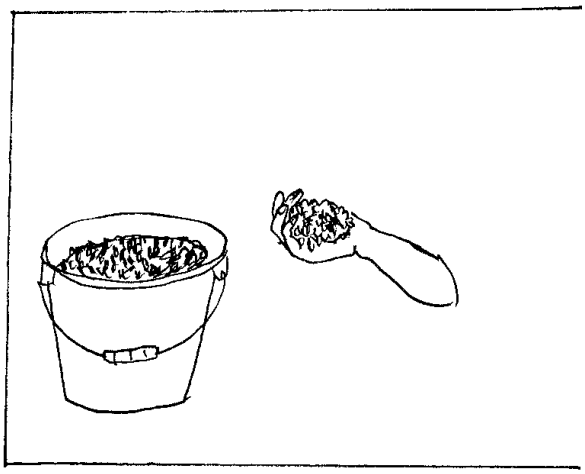
- Be careful digging compost showers in heavy clay soil as they may fill up and overflow in the wet season. Raise the height of the floor to reduce this problem and create an overflow drain to direct the excess water away.
- If you are building a compost shower on a slope, build a small drain above the shower that flows into a separate catchment, such as a swale, to catch and divert heavy rains and prevent the pit filling up in the wet season.

Washroom designs

Use whichever materials are available to make the washroom. Clay, rocks, earth-bags or cement blocks all last a long time. To protect the walls, apply a cement-based render or cover them with tiles. A rock, cement or tile floor is easy to keep clean and hygienic and it does not have to be square! You can also use bamboo, wood or palm-leaf stalk panels for the floor but they become mouldy from the moisture and need to be replaced much more often.

If you include a roof in the design, collect the run-off rainwater in a drum or tank to use in the washroom. It is also important to reuse the washroom wastewater by running it outside through a pipe, which is easier to maintain, or into a trench. Look at the section on cleaning wastewater for ideas to make the water safe to reuse. Construction and maintenance is much easier if you combine the kitchen, washroom and clothes-washing water in the same water-cleaning system.



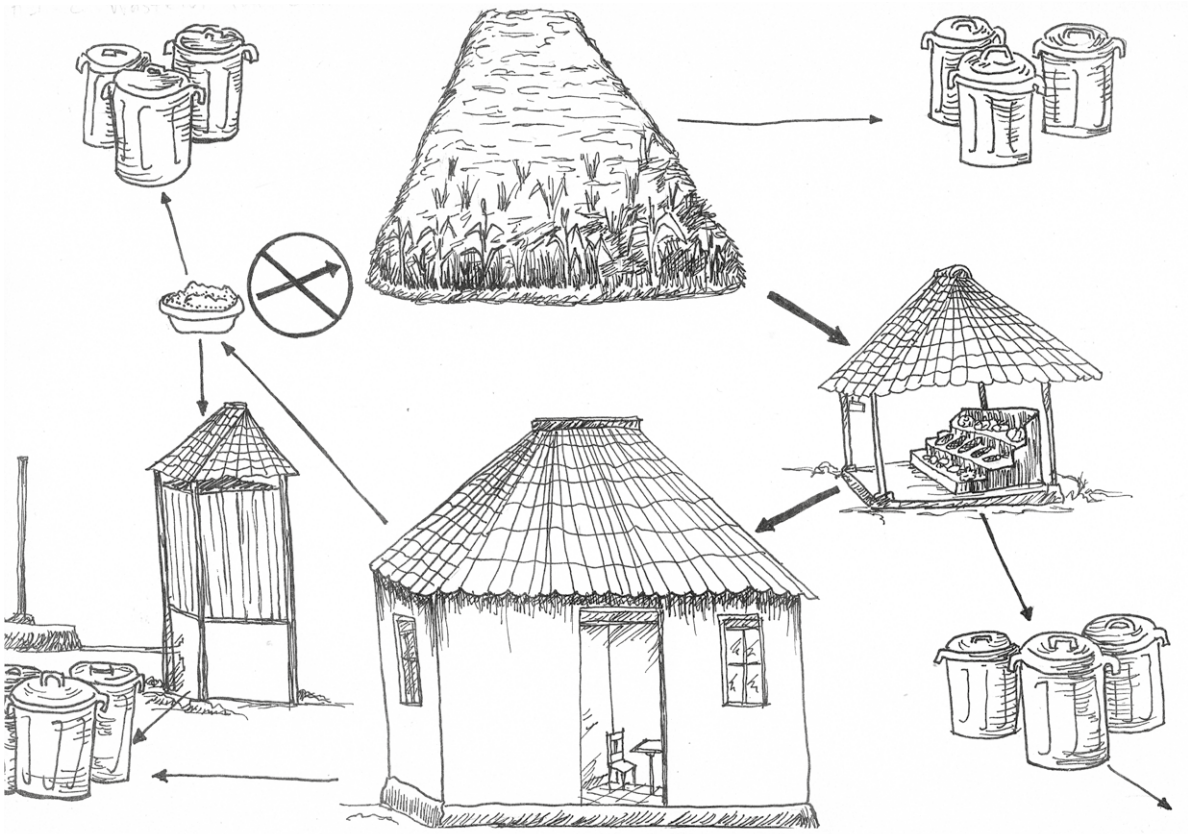


Compost toilets

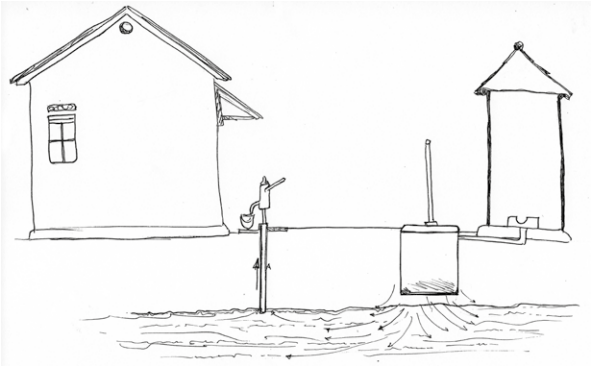
Human manure is a valuable resource and can be turned into quality fertiliser.

Humans, like other living things, take a lot of nutrients out of the soil via our food. When we do not return these nutrients to the soil via our urine and manure, we break the nutrient cycle and create a huge nutrient gap. The need to fill the nutrient gap is the same situation all over the world.

Not replacing a large part of the natural nutrient cycle or instead using chemical-based fertilisers that harm the soil contributes to climate change and has many other costs. The other part of the problem is that human manure creates a massive nutrient overload in places where it causes problems, such as in rivers and oceans.



As part of a wasteful food chain the nutrients from human manure are lost



A septic tank leaking into the underground water supply

The situation must change if communities and countries are to become truly sustainable. By processing and returning human manure to the soil, we fix both problems.

In many tropical countries reusing human manure is not considered culturally appropriate. This is partly because people do not take enough care when they dispose of their manure and it causes sickness. Current methods for dealing with human manure may look safe, but they actually create health problems. Bacteria infected water can leak from septic tanks into the ground water, which infects tap water, and also flows into rivers and oceans. Septic tanks are expensive to clean, often cleaning services are not available and in many places septic tanks are not available.

In some countries it is common for pigs to eat human manure. This is not healthy for the pigs and it can transfer diseases to the people who eat the pigs.

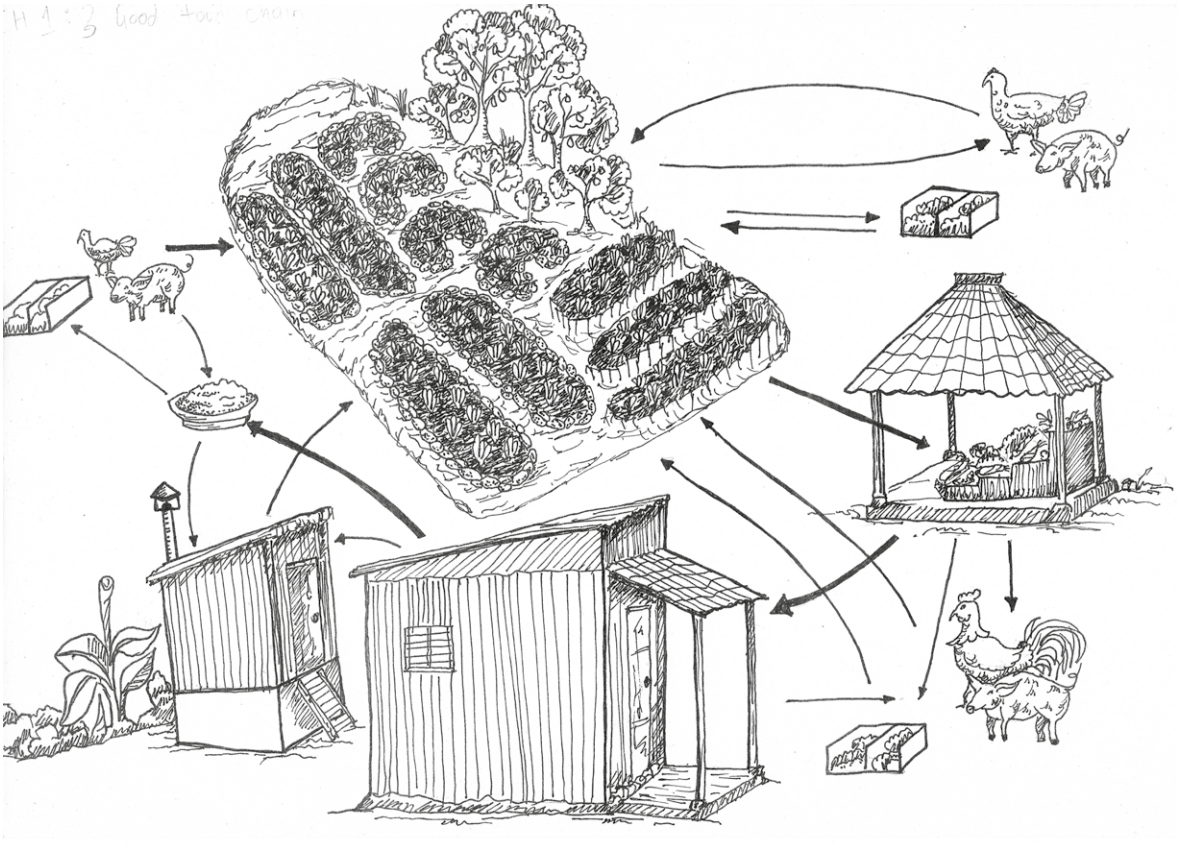
Composting toilets are a tested, safe and hygienic way to dispose of human manure, if you follow the correct composting processes. They provide disease-free fertiliser for your fruit and nut trees.

Compost toilets provide many benefits. They

- Make great fertiliser
- Use much less water – some systems use none at all
- Reduce and prevent diseases

The method turns a problem into a solution!

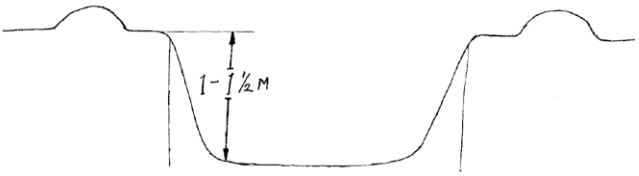
Read Urban and Community Permaculture (**Ch 4**) for processing and using human manure on a larger scale.



As part of a healthy food chain the nutrients from human manure are returned to the soil and plants

Compost toilet pits

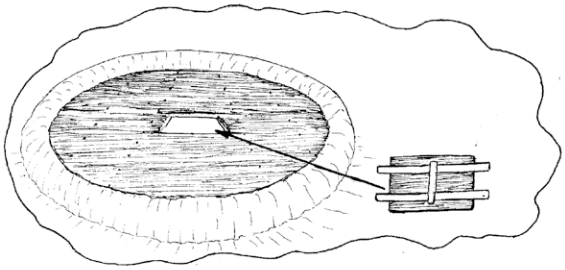
A compost pit toilet is simple to make and use.



Dig a large pit, approximately 1 metre deep and 1.5 to 2 metres across. Use the soil you dig out to make a mound around the edge of the hole.

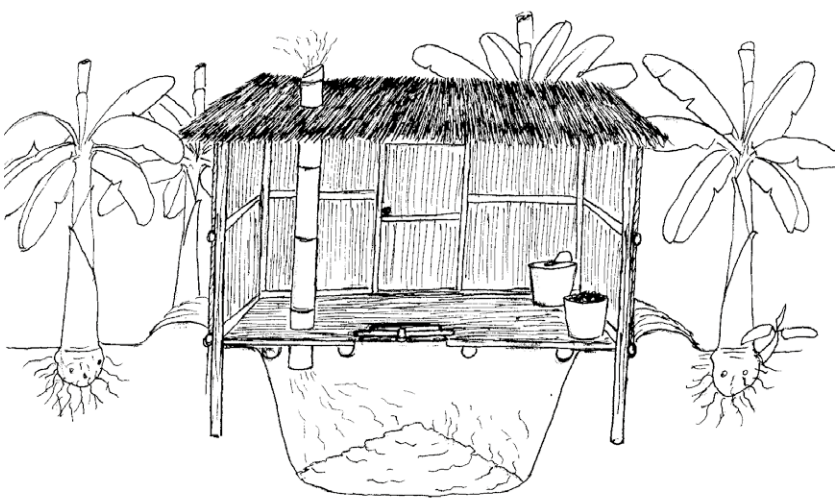
The pit needs to be as far away from rivers or other water sources as possible (at least 20 metres but 50 metres is better). The reason is that in the wet season bacteria from the toilet might enter the water source via underground water, causing sickness for water users.

Make a floor with hard wood poles and palm-leaf stalk panels or flat bamboo on top to cover the hole. To prevent flies from entering the pit cover the palm-stalk panels or bamboo with a clay/cement render. Make a small hole in the middle of the floor for the toilet hole which needs a cover for when the toilet is not being used.



Build a simple toilet house around the place to give privacy. This can be made from wooden or bamboo poles fixed in cement (see Bamboo **Ch 16**), and palm leaves or grass – whatever is cheapest and available. Position the door towards where the wind comes from most often to prevent bad smells. The roof should be waterproof to prevent water filling the pit in the wet season.

A ventilation pipe increases the speed of composting and reduces any bad smells. It can be made from a bamboo pipe with the insides removed and inserted into a hole in the floor. Use render around the pipe to seal any gaps. Add 50 cm of plastic pipe painted black to the top of the bamboo to help draw the air and smells out of the toilet.

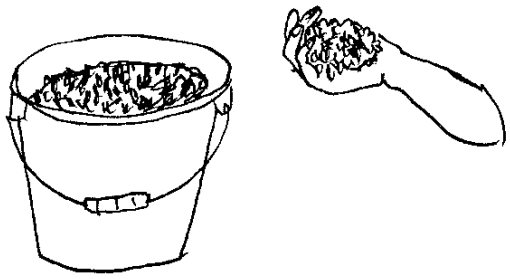


Plants: Bananas, pumpkins, luffas and passionfruit are the best plants to have around the edge. Grow citrus trees nearby. These plants and their fruit benefit from the toilet pit – the manure is too strong for most other vegetables – and they do not absorb any of the manure bacteria or its taste. DO NOT plant root vegetables that might directly touch the decomposing manure, as this can spread disease.

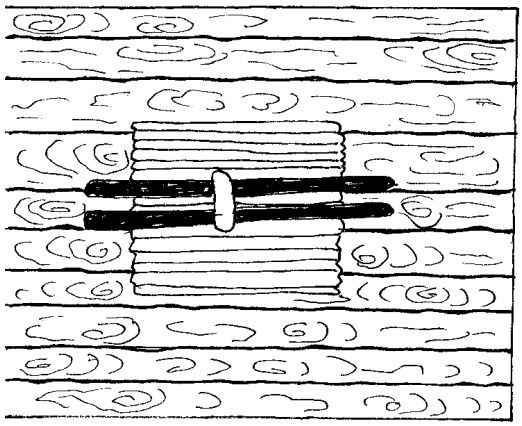
It usually takes about one to two years for the pit to fill up, though it depends on how big the pit is and how many people are using it. When the toilet pit is full, dig another pit. Add more leaves, rice husks, etc., to the full pit and let the materials rot for at least six months.

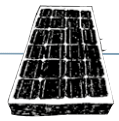
After six months, the composted manure is ready to fertilise fruit and nut trees and the toilet pit can be used again. By this time, the floor and walls of the toilet may need rebuilding.

HOW TO USE A COMPOST TOILET PIT



- Add one large handful of rice or coffee husks or sawdust every time the toilet is used. This combines with the manure to make fertiliser and stops the manure from smelling, which is very important! You can add a litre of liquid compost to provide beneficial bacteria as well.
- Add about five handfuls of wood ash or lime once a week. This helps the manure to break down faster, which makes better fertiliser and reduces the smell.
- Adding a small bucket of charcoal (See Biochar in Soils **Ch 9**) once every 3 months aids the decomposing process a lot.
- Keep a lid on the floor hole when the toilet is not being used to stop flies from entering to pit. Flies spread diseases from the manure.
- There is no need to add extra water. The manure works better with little or no added water. If appropriate men should not use the pit for urination, but feed a large fruit tree instead.





SMART IDEAS:

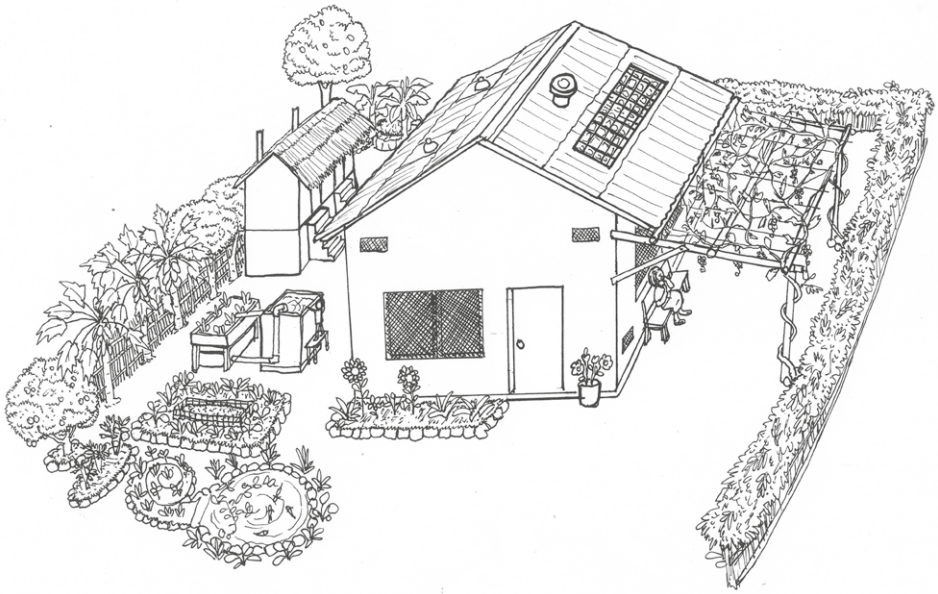
- DO NOT use the toilet pit as a place to put rubbish!
- When digging a compost toilet in heavy clay soil, be aware that the pit may fill up and overflow in the wet season. You must use a waterproof toilet roof over the pit and if flooding often occurs, this type of toilet is not appropriate for the soil.
- If you build a compost toilet on a slope, dig a small channel above the area to divert heavy rains into a separate catchment, such as a swale, to prevent the pit filling up in the wet season.
- Use bamboo to make your charcoal and ash, as it is more sustainable.

Compost toilet systems

There are many different types of compost toilets with various designs. Consult internet sites and books to show you the different types of toilets in detail, some of which are included in our reference chapter. The compost toilet described here is a cheap and simple design, easy to maintain and is used in many countries.

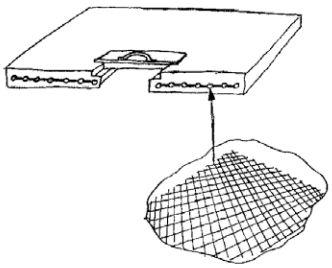
Note: This toilet, as it is described, must be adapted so you can use a small amount of water for cleaning. Other types of toilets have separators and pipes that remove the urine and water from the pit and direct it into water-cleaning systems. Toilets like these are important for Islamic people and communities, and excellent for higher toilet usage situations such as eco-tourism businesses, offices and community groups.

We recommend doing more research before attempting to build the following or any other composting toilet. If it is not built properly, it will require a lot of maintenance and will not produce safe, usable compost.



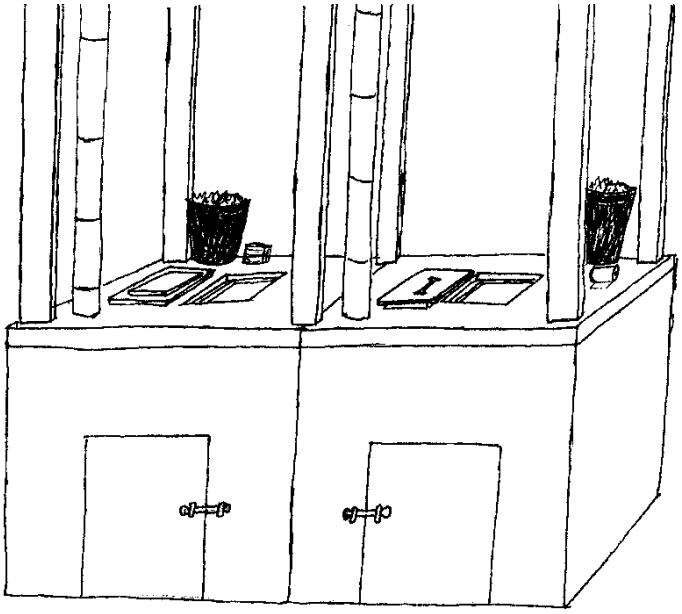
Compost toilet in an urban location

TWO-BOX COMPOST TOILETS



This compost toilet is two cement boxes joined together made from cement blocks. Each box is about 1 m x 1 m x 1 m (1 m3) on the inside. The cement blocks must be rendered inside and outside to make them waterproof. On top of the boxes, make a cement slab about 10 cm thick. It is important to use steel reinforcing rods in the cement, so the toilet can support the weight of the people on top.

On top there is a toilet hole in the middle of each box about 20 cm in diameter. Each hole needs a lid that fits well for when the toilet is not in use. Each box has a small door big enough to fit a shovel at the bottom on the back. This is to remove the compost when it is ready. A simple house around the toilet gives privacy. The easiest method is to add wooden or bamboo poles at each corner when making the cement slab. Natural materials to build the walls include palm leaves, split bamboo or grass. The toilet door should face into the wind, which helps to reduce any smells.



Ventilation pipe

As outlined above, a ventilation pipe improves composting and reduces the smell. Remove the inner core of a 1.5 to 2 metre long piece of bamboo with a wide diameter, so the air can flow through. Add the ventilation pipe during the construction of the top of the boxes so the bottom of the pipe is just inside the box. The system draws air from the box up through the pipe. Add 50 cm of black-painted plastic pipe to the top of the bamboo to increase the air flow.

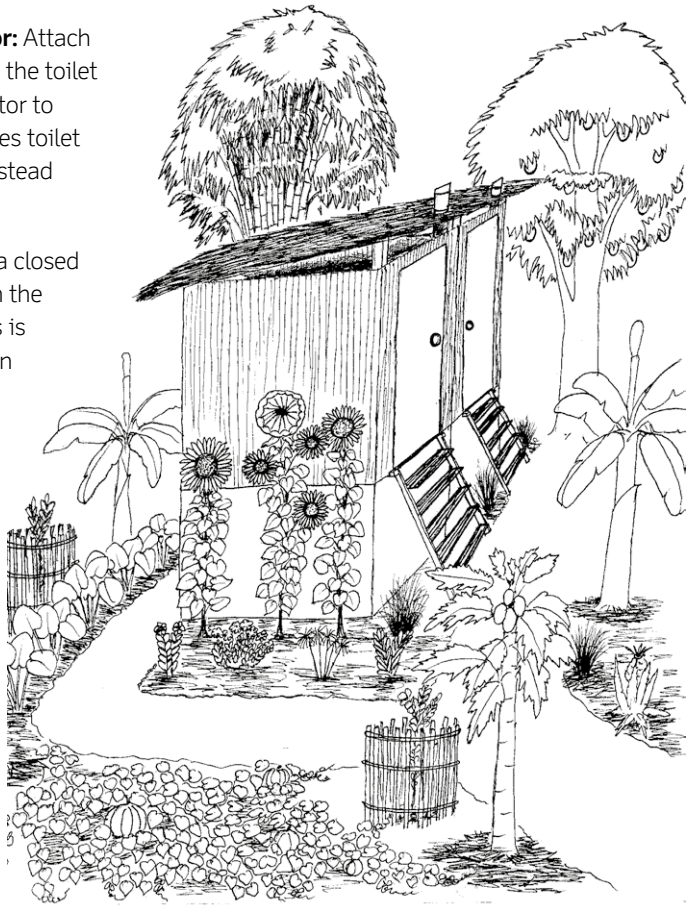
WATER USE

Option one - Closed system: This toilet design uses only toilet paper not water for hygiene and does not work with other liquids. The water floods the containers and stops the manure from composting. Men and women should urinate in a separate bucket in the toilet room. Mix the urine with water and use it to fertilise fruit trees.

Option two - Open system with overflow pipe: Add an overflow pipe to the bottom of each box to allow any excess liquid to escape. Wire mesh must be fixed to the inside of the box at the start of the pipe to stop any solids from escaping. It may get blocked and need cleaning, but the pipe improves the overall management. We recommend you use minimal or no water for cleaning.

Option three - Open system with separator: Attach a separator for urine/water and solids under the toilet seat and join an overflow pipe to the separator to run out at the bottom of each box. It improves toilet management and allows the use of water instead of paper for cleaning.

For open systems the liquid MUST run into a closed trench or wastewater garden as described in the cleaning and using wastewater section. This is because the liquid contains bacteria that can make people sick.



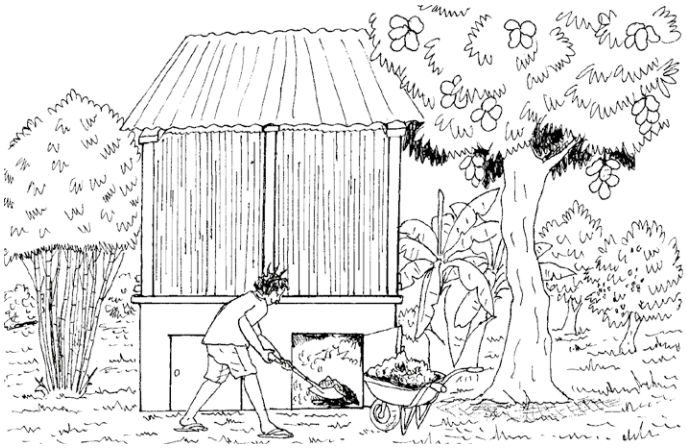
SMART IDEAS:

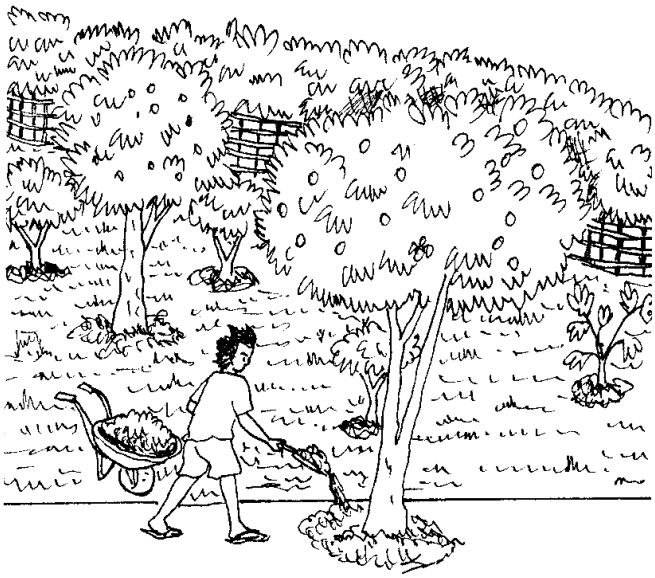
- If there are many people using the two-box toilet, it is better to build more boxes than increase their size. It is important to have enough boxes so the manure in each one has six months to break down into compost.
- Use the more sustainable option of bamboo to make charcoal and ash.

How to use (similar to compost toilet pits):

- Add a handful of rice or coffee husks, or sawdust after every use.
- Add about five handfuls of ash once a week and a handful of lime once a month.
- Add a litre of liquid compost and a small bucket of charcoal once to provide beneficial bacteria.
- Keep the lid closed when toilet is not used.
- Do not add any rubbish at all!

It takes an average-sized family about six months to fill up one of the toilet boxes. While the other side is being used, the contents of the first box take six months to become compost (no stirring is necessary). When the second box is full, remove the compost from the first box so it can be reused as a toilet. The composting process removes all the bad bacteria (pathogens) from the manure that make people sick, leaving high-quality compost to use around fruit and other productive trees, and bamboo.





Digging out and using the compost for fertilising fruit trees

SEPTIC TANKS

Septic tanks are a common method to manage human waste, especially in urban areas. Maintenance of these tanks helps to reduce bacterial contamination of the water supply and therefore reduces illness.

Three important ideas are:

- Build any septic tanks as far away from rivers and other water sources as possible. Leakage from septic tanks can pollute the water supply and make people sick.
- Add a small amount of lime once a month to help balance the PH level. (PH is the measure of acidity or alkalinity – look at **Ch 9** – Soil for an explanation.)
- Do not use bleach or chemicals to clean the toilet. They kill the good bacteria that are necessary to break down the manure properly. Instead use vinegar, add citrus skins or 1 ml of clove oil to the toilet and the system works even better.

Compost toilets are recommended above septic tanks, even for urban areas, because:

- Septic tanks leak into the underground water table. The liquid leaking out contains harmful bacteria (pathogens) that cause sickness. Compost toilets contain and decompose all manure and remove harmful bacteria
- Human manure is a valuable resource that is mostly wasted; until human manure is recycled into compost and used, humans will struggle to live sustainably.

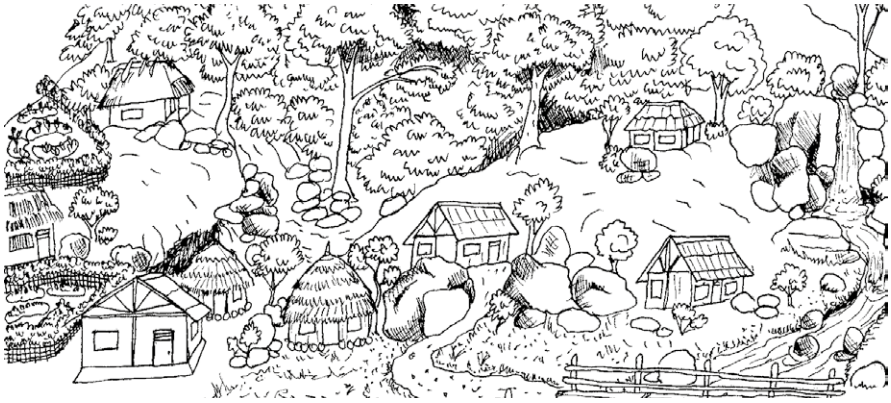
Water supply and storage

Reforestation

Forests in mountains, valleys, river edges, around villages and towns are ESSENTIAL to protect water supplies, to reduce water runoff and store water because they:

- Allow more rain to soak into the ground, reducing erosion.
- Keep the store of underground water more constant. This is very important for the future water supply.
- Provide leaves for mulch, which also helps to store more water in the ground.
- Reduce strong winds that dry out the ground.

Forests are especially important in places where communities collect water from underground sources. Without forests the water level below the ground drops, making it harder to collect water from wells and springs, reducing the quality of the water. This has already happened in many countries.

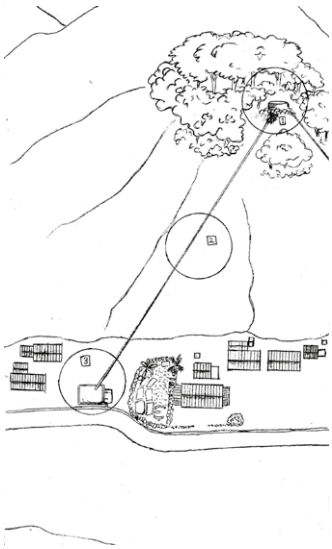


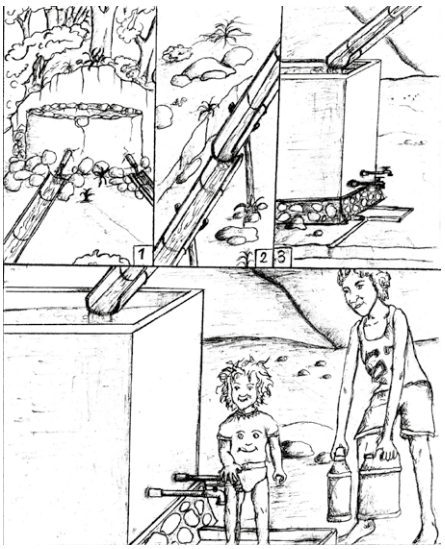
Collecting water

Collecting water is hard work that can take many hours each day. Women and children do most of the water collection.

If people can collect clean water close to their houses, the time and energy saved can be used for other activities. This improves the life of the whole family.

There are many different water collecting and storing techniques families and communities can use.





Water pumps

Collecting water is especially hard work if people have to carry it up hill. There are ways of pumping water up from the ground or uphill from a river.

One way is a motor pump but they are expensive, need petrol to run and require maintenance and repairs. Some pumps do not need petrol and are much simpler to maintain.

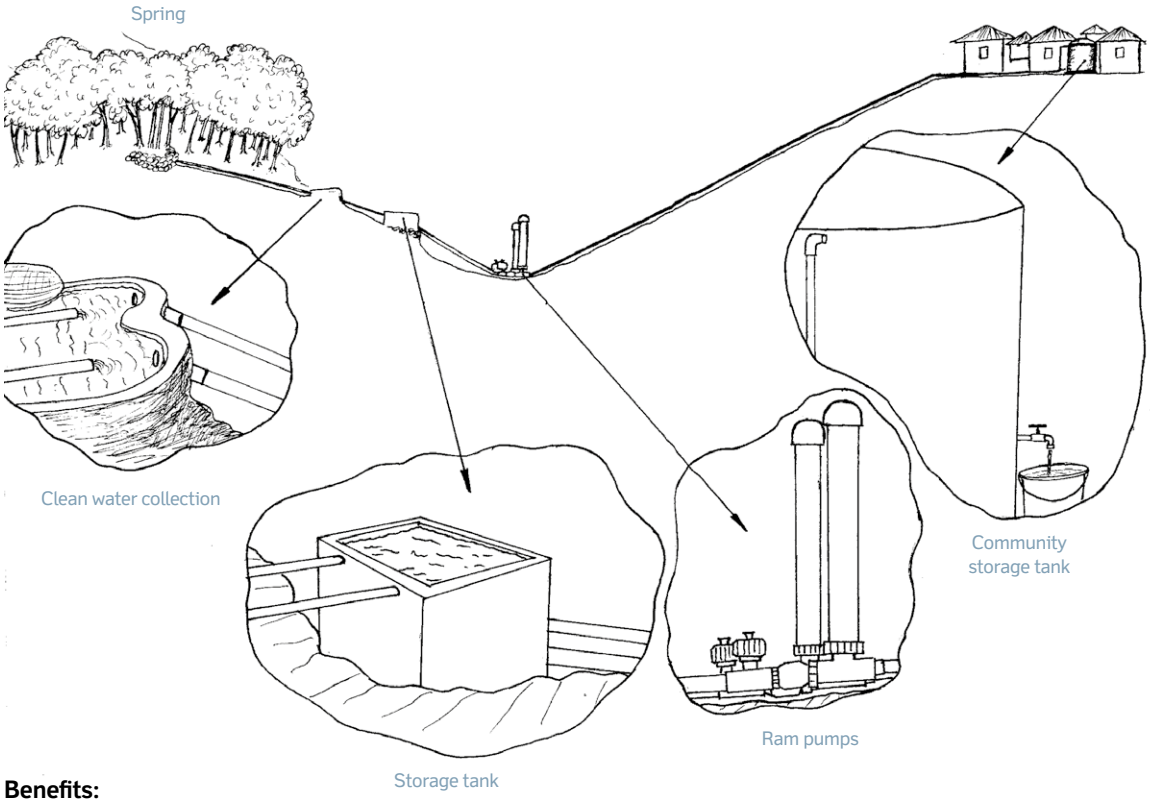
RAM PUMPS

A ram pump uses water pressure created by gravity to move water a long way uphill. They cheap, simple and require very little maintenance. Some types of ram pumps can be placed directly into a clean constantly flowing river.

Other types of ram pumps move water from springs with a constant flow:

- Water from a spring or another water source collects in a holding tank next to the spring. It is very important that the water is clean, as dirt causes problems for the flow.
- From the holding tank the water flows downhill through a large pipe about 10 to 20 metres long. Pressure increases as the water runs downhill.

Both types of ram pumps work the same way to move water uphill from rivers and springs to a village or household water tank. The water flows into the pump, creating air pressure, which then forces a piston up and down, and the action moves the water into smaller pipes up the hill. The pump moves the water continuously up through the smaller pipes for a few hundred metres!



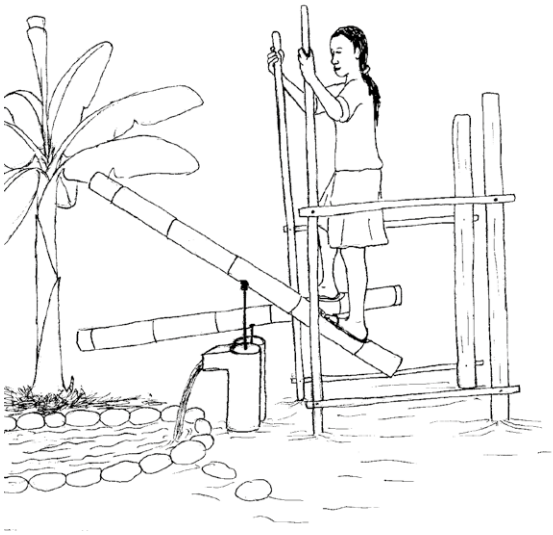
Benefits:

- They are excellent for transporting larger amounts of water and can supply many households.
- They are simple to use and maintain.
- They require NO petrol and have NO engine.
- If there is a constant water supply they can be used all year.

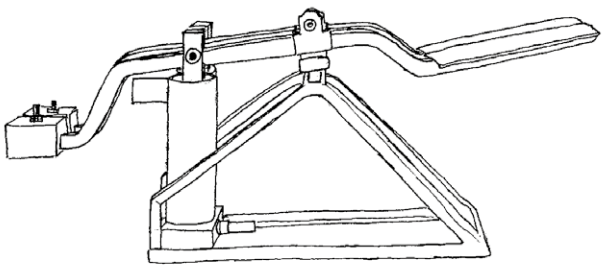
Ram pumps have been very successful in remote villages and are a great long-term water supply solution for tropical mountainous regions.

FOOT AND TREADLE PUMPS

Foot and treadle pumps bring water up from a bore or well and can also pump it from a spring or river. They operate by people treading on two boards, connected to two cylinders below them. The walking action moves the boards up and down, which drives pistons inside the cylinders. The moving pistons create air pressure which sucks water up through a pipe into the cylinders and out the top. Thus, water is drawn up the pipe and runs via irrigation pipes or to a tank for household use. The method is similar to a hand pump, but it moves more water with less effort.



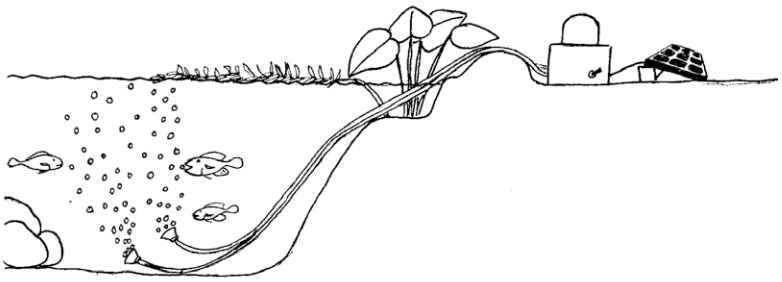
Pump in action



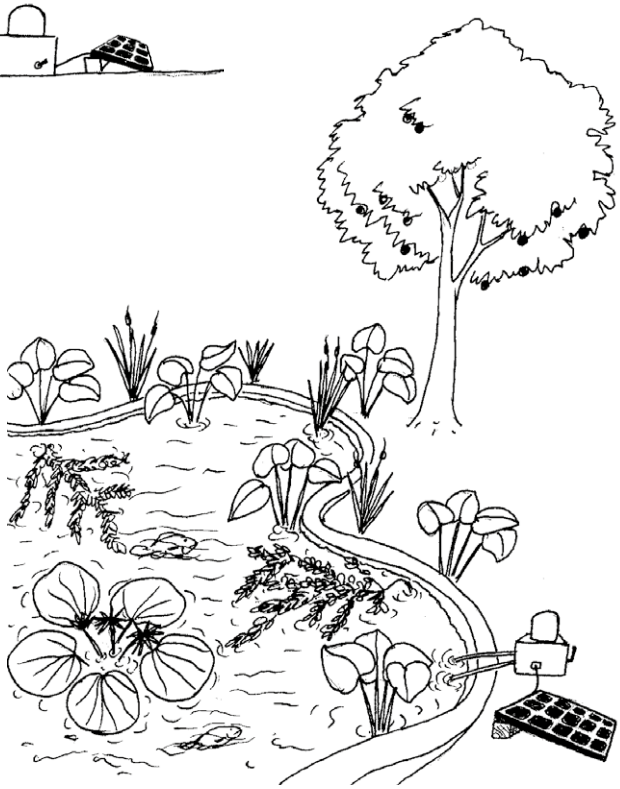
Pump mechanics

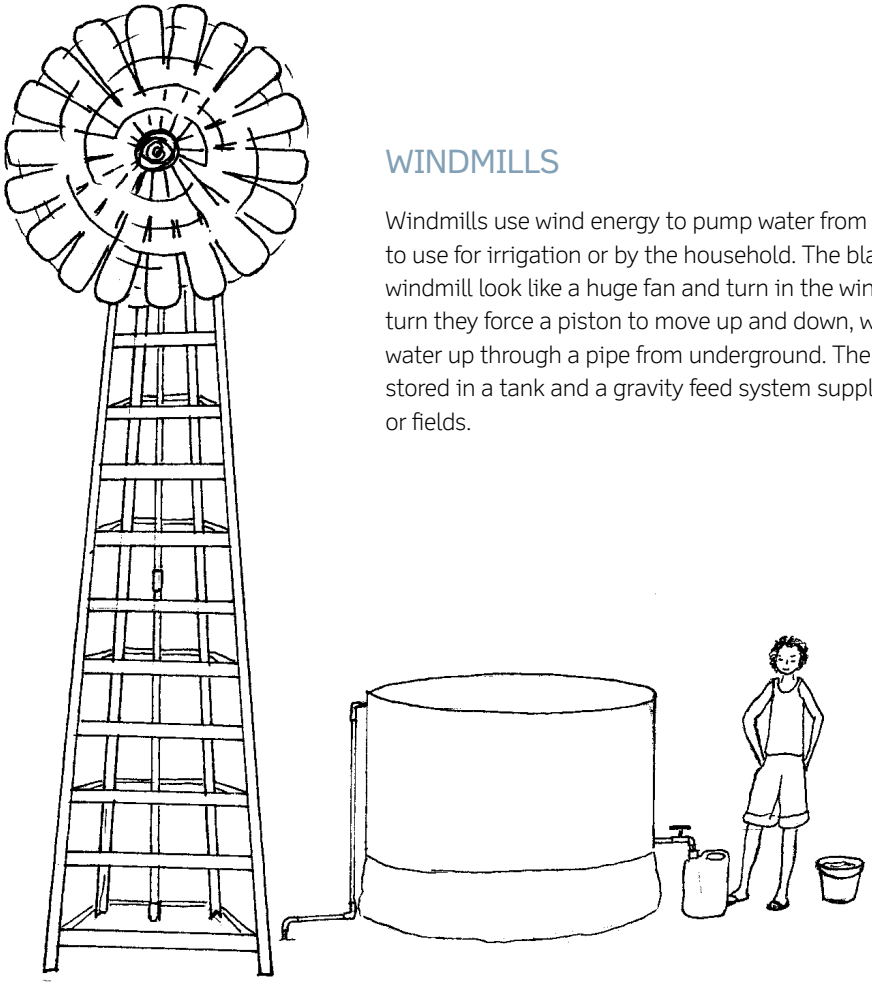
SOLAR-POWER WATER PUMPS

A small solar panel uses energy from the sun to generate the electricity to run a pump. Small solar pump systems add oxygen to fish ponds, ponds for urban yards and water-cleaning systems.



Cross-section of pond with solar pump





WINDMILLS

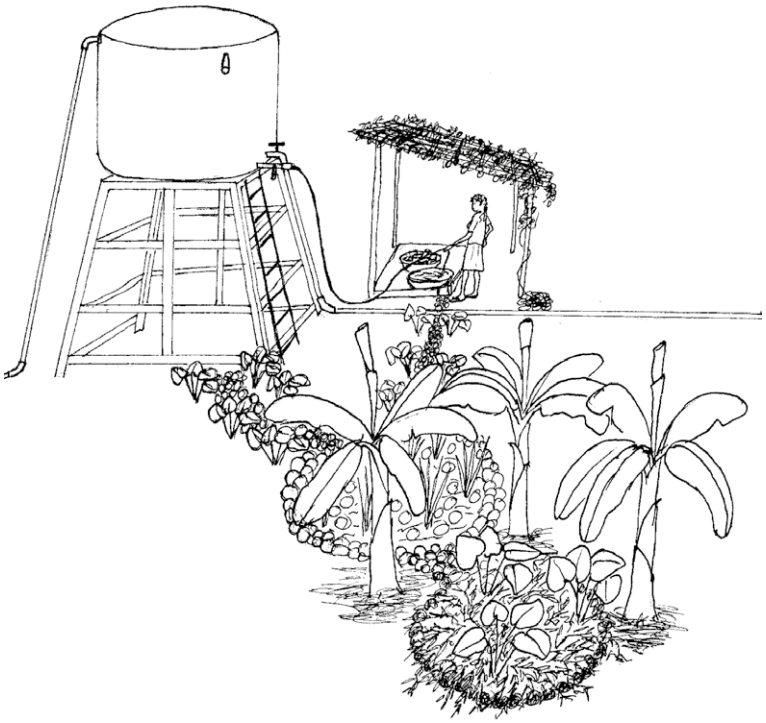
Windmills use wind energy to pump water from bores or wells to use for irrigation or by the household. The blades of the windmill look like a huge fan and turn in the wind. As they turn they force a piston to move up and down, which sucks water up through a pipe from underground. The water is then stored in a tank and a gravity feed system supplies the houses or fields.

ELEVATED WATER STORAGE

The reason for raising a water tank above the ground is that the water from the tank flows a longer way through pipes, bamboo or hoses because of gravity (moving the water downwards). This makes watering much easier and gravity carries the water further from the tank.

There are many ways to move water into an elevated tank:

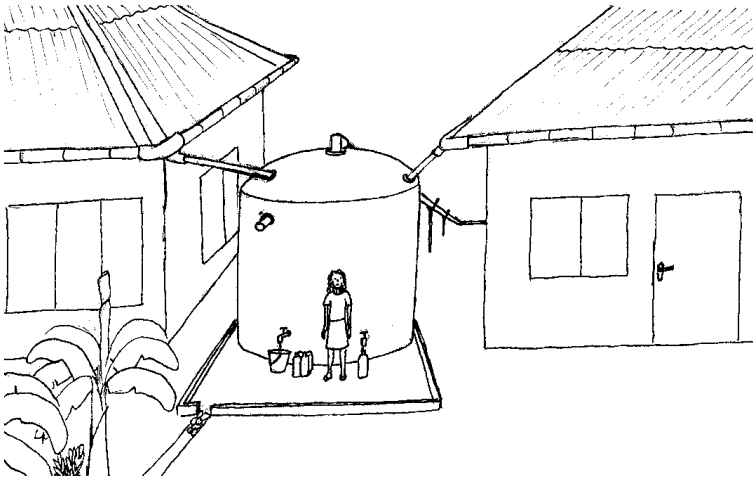
- Straight from a roof using bamboo gutter for water collection
- Use a pedal, treadle or ram pump to transport water into the tank.
- Using a petrol pump (other pumps are much cheaper and much more sustainable.)



FAMILY / HOUSE TECHNIQUES

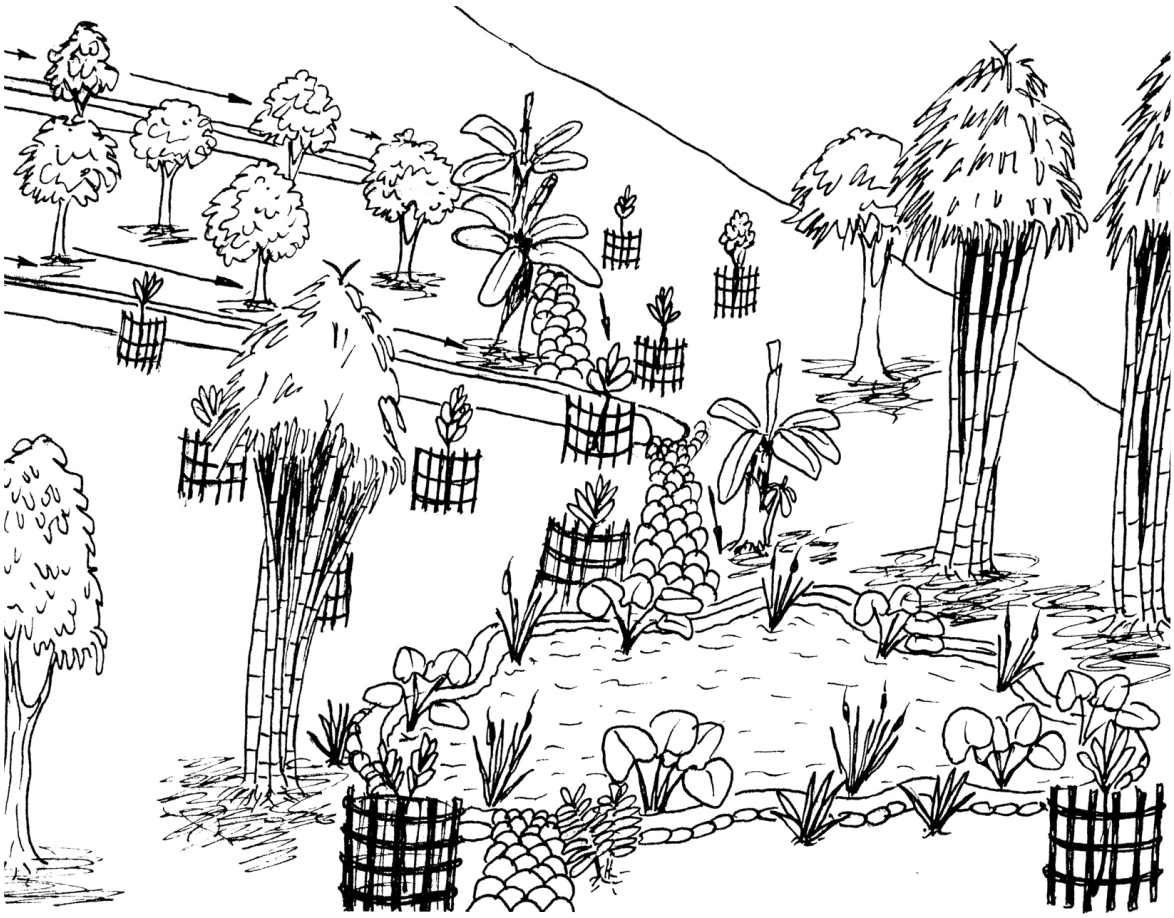
- A galvanized iron roof (on a house, kitchen or washroom) catches a lot of water when it rains. Use a piece of bamboo cut in half as a gutter to collect the water and run it into a tank or drum. You can collect rainwater from bamboo and grass roofs too.

  Community idea: A bigger tank can collect water from many roofs, but do not forget to turn the tap off after using it!



BE VERY CAREFUL: some galvanized iron roofing contains small amounts of lead that can cause sickness if you drink the water! Please make sure the galvanized iron you use is safe before you drink. If the water is contaminated with lead, you can still use it for watering the garden.

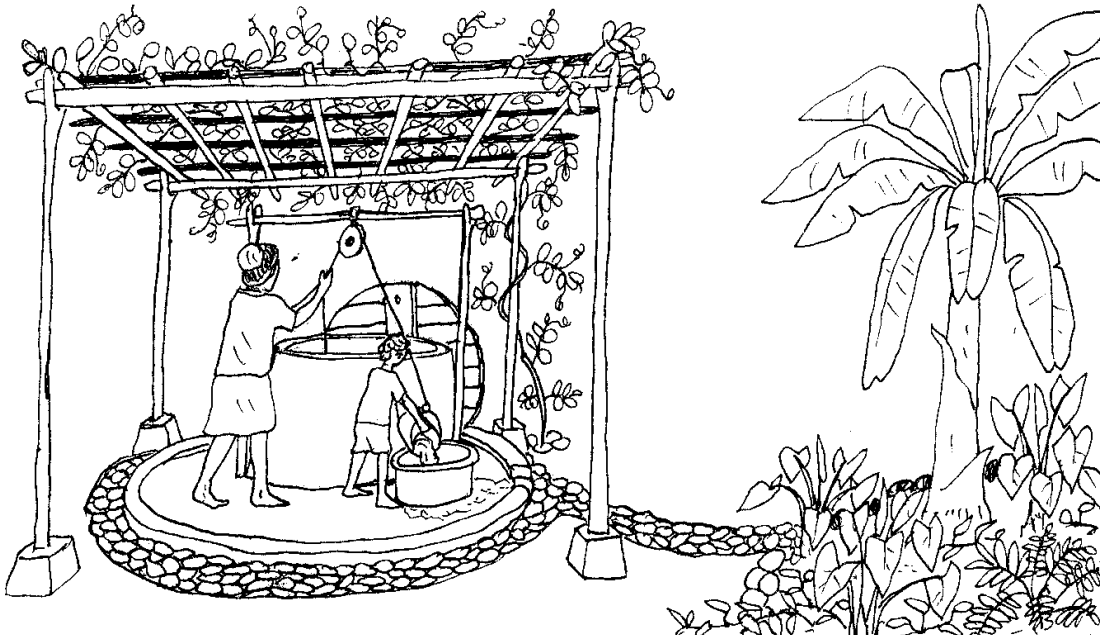
- Supply your house with water using pipes made from metal, PVC or even simple bamboo.
- Swales and trenches can collect water for gardens and ponds. Dig the trenches so the water runs very slowly in one direction. At the end where the water runs to, make a secure overflow point with rocks. You can then channel this water into a pond or water storage hole lined with clay or strong plastic for animals, vegetables and fish.



COMMUNITY WATER COLLECTION

There are a number of ways to ensure the community has the water it needs every day.

- Water springs are traditional sources of water that need protection from animals, rubbish and damage. A separate animal drinking hole is a good solution. Transport water to communities along bamboo, metal or PVC pipes and store it in large cement storage tanks. The overflow from the storage tanks can water fruit trees and vegetables using pits or swales. Using the overflow water in this way also reduces mosquito problems.
- Water pumps and bores are another good way to collect water from close to the house. They can provide water for individual houses but are much cheaper for groups of houses or communities.
- A community well is another traditional water source. Community well water must be kept clean because sickness spreads quickly from dirty water. A metre-high circle around the edge using rocks and mortar or cement protects the well, with steps added for children. This stops dirty water returning into the well and prevents animals making the well dirty. Make a separate place for animals to drink. Do not use dirty buckets or containers to collect water. **A cover for the well reduces mosquito problems and a simple shade structure makes collecting water more comfortable.**

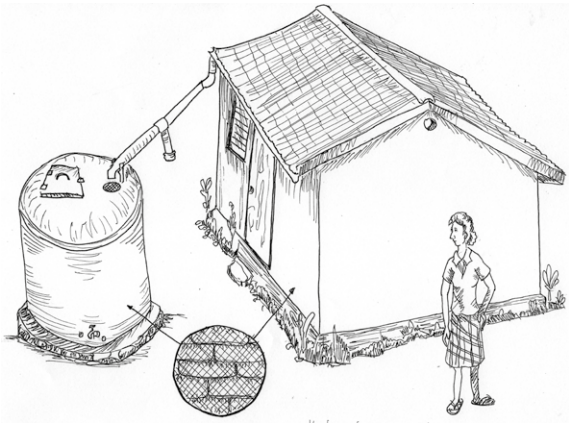


- Pump water up hill to storage tanks using ram pumps. Ram pumps (unlike petrol pumps) use NO petrol, require much less maintenance and last much longer.
- A bigger more expensive solar-panel pump system with greater capacity could be a community investment project, to supply water to between 30 to 50 households. A 30 metre bore requires about 16 solar panels generating 100 watts of energy to draw up between five to eight litres of water per second to store in a communal elevated tank for village use.
- Communities can work with the government to bring in water from a nearby town or village if it is available.

Storing water

It is important to store water and storage tanks with taps make using the water easier. A storage tank catches water from pipes, pumps or water caught from a roof. They are generally made from concrete, plastic, tin, but can also be made using the earthbag building technique described in the houses section. Large clay pots traditionally store water in many regions.

Making an earthbag rainwater tank



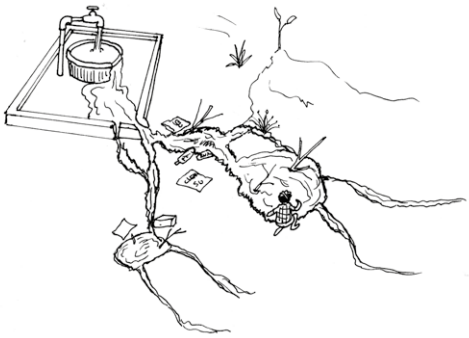
Completed earthbag rainwater tank

Petrol drums are another way to store water, especially to catch rain from roofs. They must be cleaned very well to remove all the petrol:

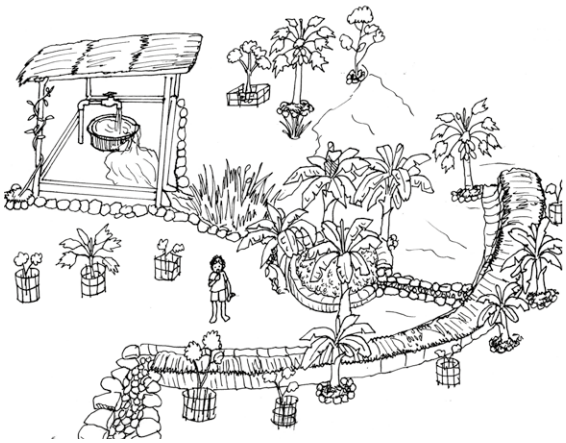
- Wash and scrub the drum thoroughly with detergent.
- Rinse it out completely with water.
- Leave the drum in the sun for a week before use.

SMART IDEAS:

- A simple shade structure or shade trees to protect the tank from direct sunlight improves the water quality and helps the tank, especially those made from plastic, last longer.
- In mountain areas where it gets cold at night, drops of water collect on the tin roof sheets (condensation as water vapour changes into liquid form). It may not be a lot but collect the water and store it, especially in the dry season. Collecting a little on most cold nights reduces the hard work of carrying water.
- Store rain in the wet season. Try to collect some of the wet season rains from the roof to save in tanks. By creating ponds and planting trees you can store the extra water in the ground. Trees store water in their roots, trunks, branches and leaves.



Wherever the water comes from, it must not be wasted or cause problems



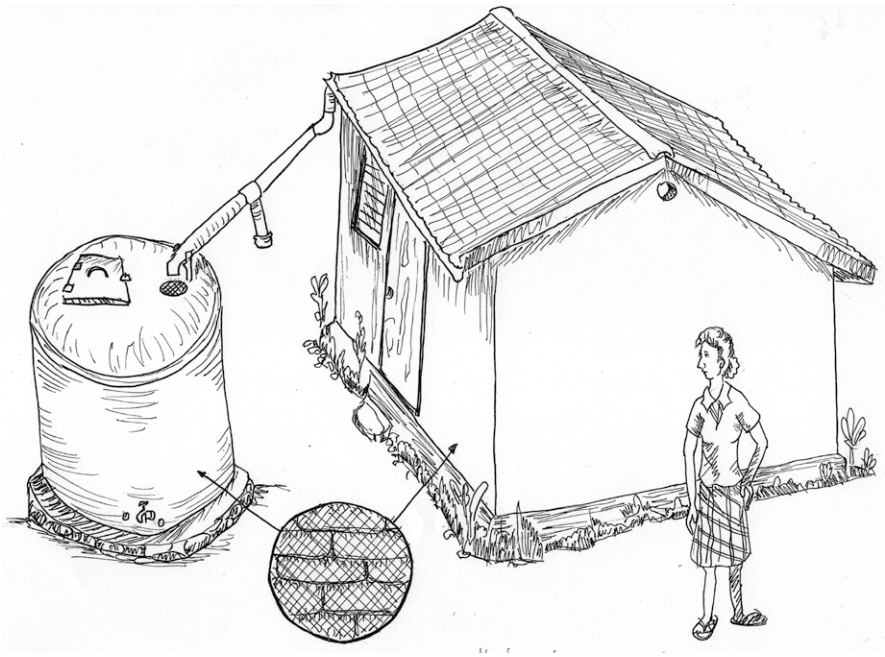
Water overflow being re-used efficiently and productively

KEEPING WATER CLEAN

When catching rainwater from roofs it is best to allow water from the first rain to run off rather than let it go straight into the tank, especially if it has not rained for a while. The first lot of water contains dirt, bacteria, leaves and other items from your roof and you do not want these in the tank.

It is important to keep house water stored cleanly to reduce the chances of sickness.

- Cover storage tanks and drums at all times. Stop mosquitoes from breeding by using strong insect screen secured over inlets.
- Do not use dirty buckets or containers to remove water, especially if there are no taps.
- Use crushed Moringa seeds, read below.
- Check the water source regularly to make sure it is clean and flowing normally – maintain it if necessary: for example, springs, bamboo pipes, roof and gutters.



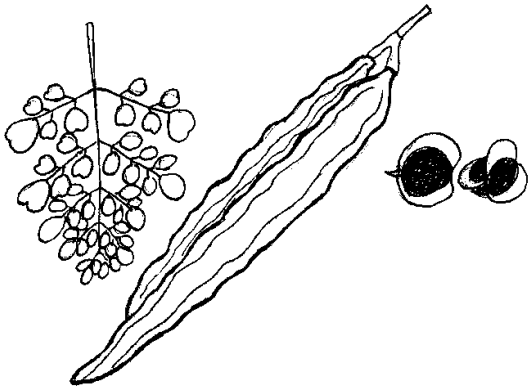
Rainwater tank with first rain release valve and protection from mosquitos

Purifying water for drinking

MORINGA SEEDS

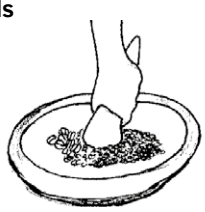
People in parts of Africa, India and other countries use the seeds of the Moringa tree to remove dirt and most bacteria from water. It is a simple, effective way to make dirty water drinkable (potable) and prevents A LOT of sickness and even deaths, especially for children. It also saves A LOT of firewood, hard work and time because there is no need to boil the water.

Moringa treatment does not remove 100% of water pathogens (bad bacteria), but it is usually between 90 to 99% successful. Water purified by moringa seeds should also go through a water filter if possible.

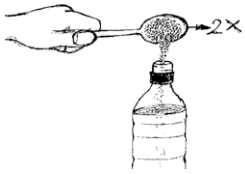


How to use the Moringa seeds

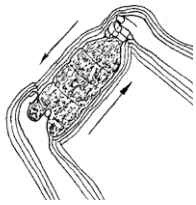
- Remove some seeds from the pods and remove their outer shells, leaving the white seeds.



- Crush the seeds into a fine powder. Do not use discoloured (brown) seeds.



- Mix two small spoons of powder with water in a clean plastic bottle.

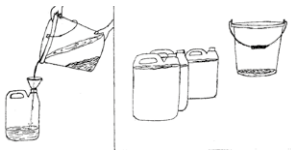


- Shake the bottle for five minutes.

- Pour this solution, through a clean cloth to remove any remaining solids, into the bucket of water to be treated.

- Stir the water fast for two minutes, then slowly for ten minutes.

- Leave the water in the bucket for an hour undisturbed. The dirt and bacteria stick to the Moringa seed powder and sink to the bottom of the bucket.

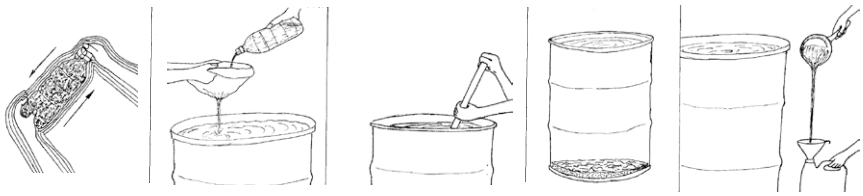


- Carefully pour the purified drinking water into clean bottles or storage containers, leaving the sediment in the bucket. Do not allow the sediment to re-contaminate the purified water.

CAREFUL: Follow the process of shaking and stirring closely to activate the water cleaning properties. This ensures that the process works quickly and effectively.

Community idea

Moringa seeds can purify large amounts of water as well. Use Moringa at a rate of a kilogram of seed powder for 10,000 litres of water (approximately 1 gram for 10 litres).



WATER-PURIFYING FILTERS

Water filters remove bacteria and other impurities that make people sick. The result is not just clean drinking water. As the water does not have to be boiled before drinking, the benefits are:

- It saves A LOT of work!
- And it saves A LOT of wood, which means that it saves money!
- People's health is significantly improved by reducing the risk of diarrhoea from water-borne diseases, especially in children.

There are many different types of water filters.

Clay

The clay is shaped into bowls that are then fired (baked at extremely high temperatures) in a kiln, a large oven for preparing items made out of clay. The slow heating and cooling process changes the soft clay into a hard water-proof ceramic that is good for filtering water.

The bowl for filtering the water is made from a specific type of clay or there is a special clay/ceramic base inserted in the bottom of a metal or plastic container. The water slowly passes through the base.

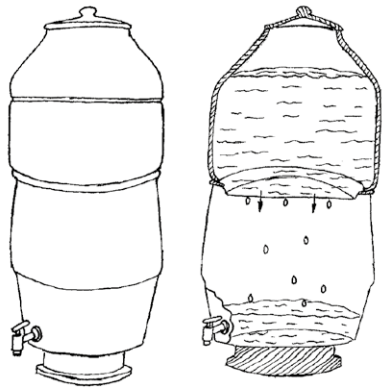
How clay water filters work

Clay is made up of millions of very small particles or fine grains containing different elements. The clay particles join together, leaving small holes (or pores) between them through which water can only pass slowly. Different types of clay have different size particles, so the spaces between them vary. The clay used to make water filters has very small pores, which prevent up to 98% of bacteria in unclean water from passing through. Any bacteria in the water stay inside the filter bowl, making the water that passes through safe to drink.

Clay water filters MUST be fired in a proper kiln to work effectively. The slow temperature changes during the firing process reduce the size of the spaces between the particles and the elements in the clay create new strong bonds to form ceramic. It is important to use the right clay for the kiln as:

- If the holes in the clay are too small, the water takes too long to flow through.
- If the holes are too large, the bacteria pass through and the water is not clean.

This is why careful clay testing and proper firing must happen so that the water filters work properly.

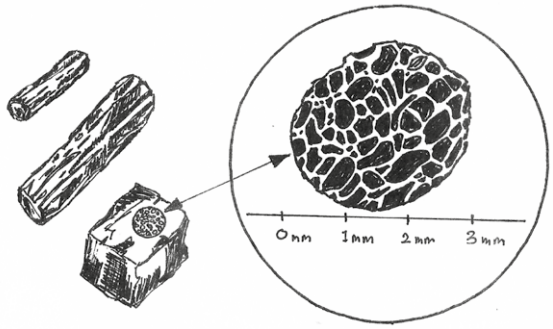


How to use a clay water filter

Water filters are very easy to use. Simply pour the water into the top bowl. The water slowly filters through to collect in a bowl below it. As it does the bacteria and dirt are caught and stay in the top. Drink the water from the bottom bowl. The base of the top bowl might become blocked by the bacteria and other materials that it catches, so clean it occasionally to ensure it continues to work well. Only use a brush, boiling water, lime juice and vinegar to clean it.

Crushed charcoal

Crushed charcoal is a good water filter, especially charcoal made from the biochar technique. It is a simple filtration system and removes most chemicals, dirt and other particles by absorbing them as the water flows through. Bigger bacteria are also removed but the charcoal in the filter needs to be changed regularly for it to continue working effectively.



Sunlight

Sunlight can purify drinking water: simply leave a clean glass bottle full of water in direct sunlight for six to eight hours or for two days, if the weather is cloudy. Bacteria, parasites and viruses are killed by the ultra violet (UV) radiation from the sun through a process called solar water disinfection (SOLDIS). Turn the bottles twice during the day. This simple easy technique significantly improves your family's health by removing the pathogens that cause diarrhoea from the water.

This method guarantees that the water is 99% safe from microorganisms, but make sure there are no chemicals in the water you use for SOLDIS. Collect the water from clean rivers or streams, not from areas where the water could be polluted. If the water has dirt particles, remove them by straining the water through pieces of clean cloth first. It is better to use glass bottles, but if they are not available, clean used PET plastic bottles (polyethylene terephthalate with the number 1 recycling code on the bottom) no bigger than two litres are almost as good for SOLDIS.

Ultra violet (UV) and solar disinfection for large-scale water purifying are becoming more widely used in villages, towns and cities.

Salt water distillers

There are now small solar ovens for making salt water potable. This not only means that you can create drinking water from seawater but it also reduces risks of water-borne diseases. A cheap simple version of the water distilling solar oven is made out of clay with two tanks – one at the top to fill with seawater and the other to catch the drinking water after it condenses, having been heated by the sun.

Look in the reference section for where to find more information about different water filters.

COMBINING WATER-PURIFYING TECHNIQUES

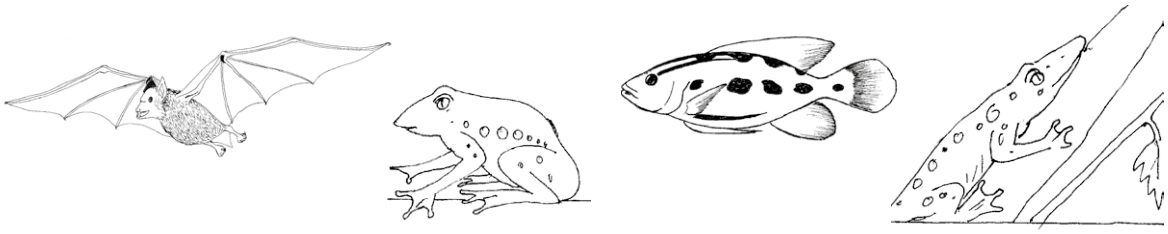
By combining two or more water purifying techniques you can achieve better results. This is highly recommended to reduce disease risk. The water filters also work for longer and need replacing less often. For example:

- Purify large amounts of water with Moringa seeds, then put the water in a water filter as needed.
- Silver nitrate (a natural antibacterial material) can be added to clay and charcoal filters.
- Use two of the following: solar disinfection in bottles, a clay filter and charcoal filter.

Reducing mosquito problems

If you collect extra water in the wet season into ponds or banana pits using trenches and swales, it prevents water from lying in pools on the ground. **Mosquitoes are then only able to lay their eggs in the pond.**

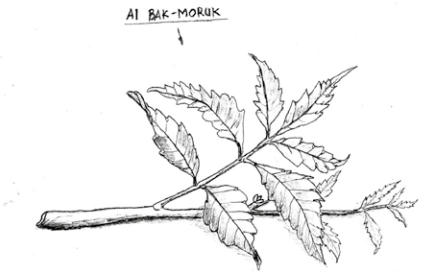
The fish, frogs, small lizards and other insects living in and around the pond eat the mosquito eggs and larvae in the water. The cycle greatly decreases mosquito numbers and the diseases they spread, **so everyone's health benefits**. The insects and small animals also remove some of the pest insects that eat vegetables.



Beware: Chemicals from pesticides and herbicides can kill a lot of plant and animal life in ponds and aquaculture systems, so do not use them.

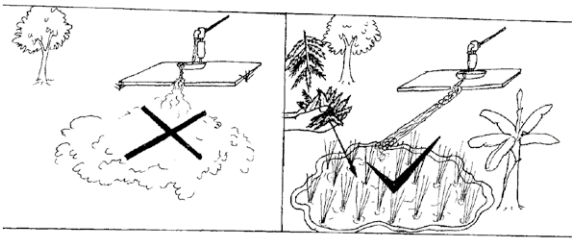
Other important steps for reducing the mosquito population:

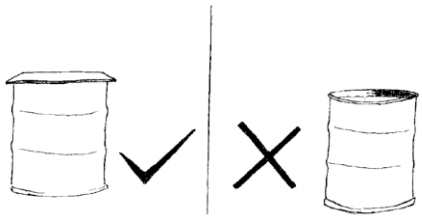
- Do not allow water to lie in pools on open ground or to collect in discarded containers.
- Treat all wastewater properly and do not leave it sitting around.
- Cover all water tanks and containers.
- Put small fish (Tilapia are best) into the water saved to wash clothes and water containers that are not for drinking. They eat the mosquito larvae.
- Fish in rice paddies eat a lot of mosquito eggs and larvae.
- Prune off old banana leaves continuously as mosquitos like to hide underneath.
- Make sure you remove rubbish and unwanted items from around your house to prevent mosquitos from hiding in dark areas.
- **Neem**: place a cup of neem fruit/seeds and four cups neem leaves in a cloth with a rock, tie it up then sink it in your pond or big non-drinking water containers to release neem oil slowly into the water. Or add 20 ml of neem oil. Repeat every three months

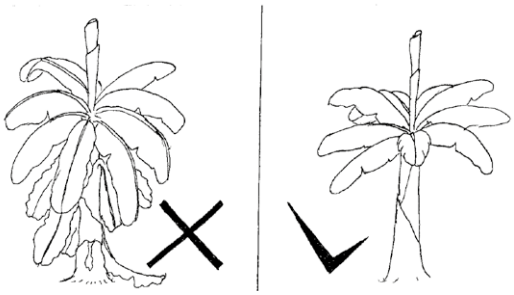


- For banana pits. Do not allow water to sit in the top layer of leaves. Soak a full bucket of neem leaves in water for two days and pour the liquid, with the neem leaves, into each pit. Repeat every three months.

Reducing mosquito problems involves a communal and a national strategy. Education about disease prevention and mosquito life cycles is very important. **Keeping the community water supply free of mosquitoes also helps a lot.**







Renewable energy

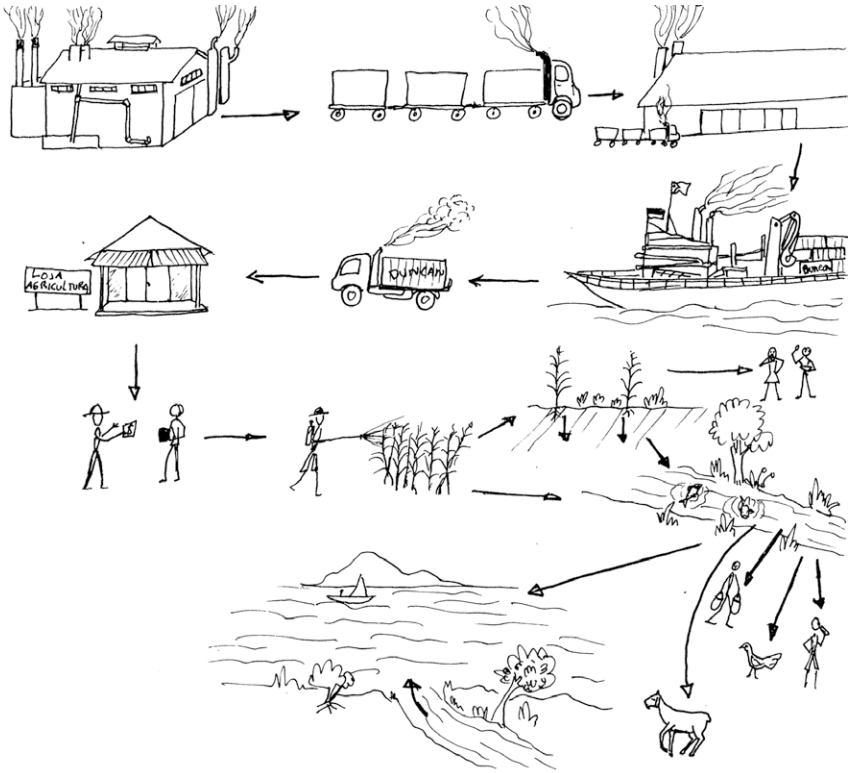
Many areas in tropical countries do not have regular electricity. This is because:

- Infrastructure is poor.
- Petrol is too expensive.
- Generators are often either old or badly maintained so they break down.

In the areas where the electricity supply is regular, there is not much thought about how the electricity is generated, the pollution it causes, or how much is used.

CLIMATE CHANGE

We are currently facing a world crisis from global warming and climate change because we have not considered the consequences of our actions. Our means of transport and our electricity have been fueled mostly by coal and oil, which are both non-renewable resources that create a lot of pollution. They were initially cheap and are very rich in energy, but we have used too much too quickly and our planet is warming up from the pollution caused by burning these fuels.



The process of making, transporting and using chemical pesticides and herbicides is one example of how we have created pollution and climate change

Climate change is already occurring, but if we change quickly we can still minimise the impacts and consequences on our planet, our environment and our climate. If we do not act, climate change will get a lot worse, making even basic survival very hard.

BENEFITS OF RENEWABLE ENERGY

An important solution for addressing climate change is to switch to using renewable energy sources now. Renewable sources continually provide energy which can be turned into electricity such as solar/sun, wind, biogas, hydroelectricity, geothermal, tidal ocean energy. We also must change the fuel we use for cars and other forms of transport to renewable energy. (See later in this chapter about transport.)

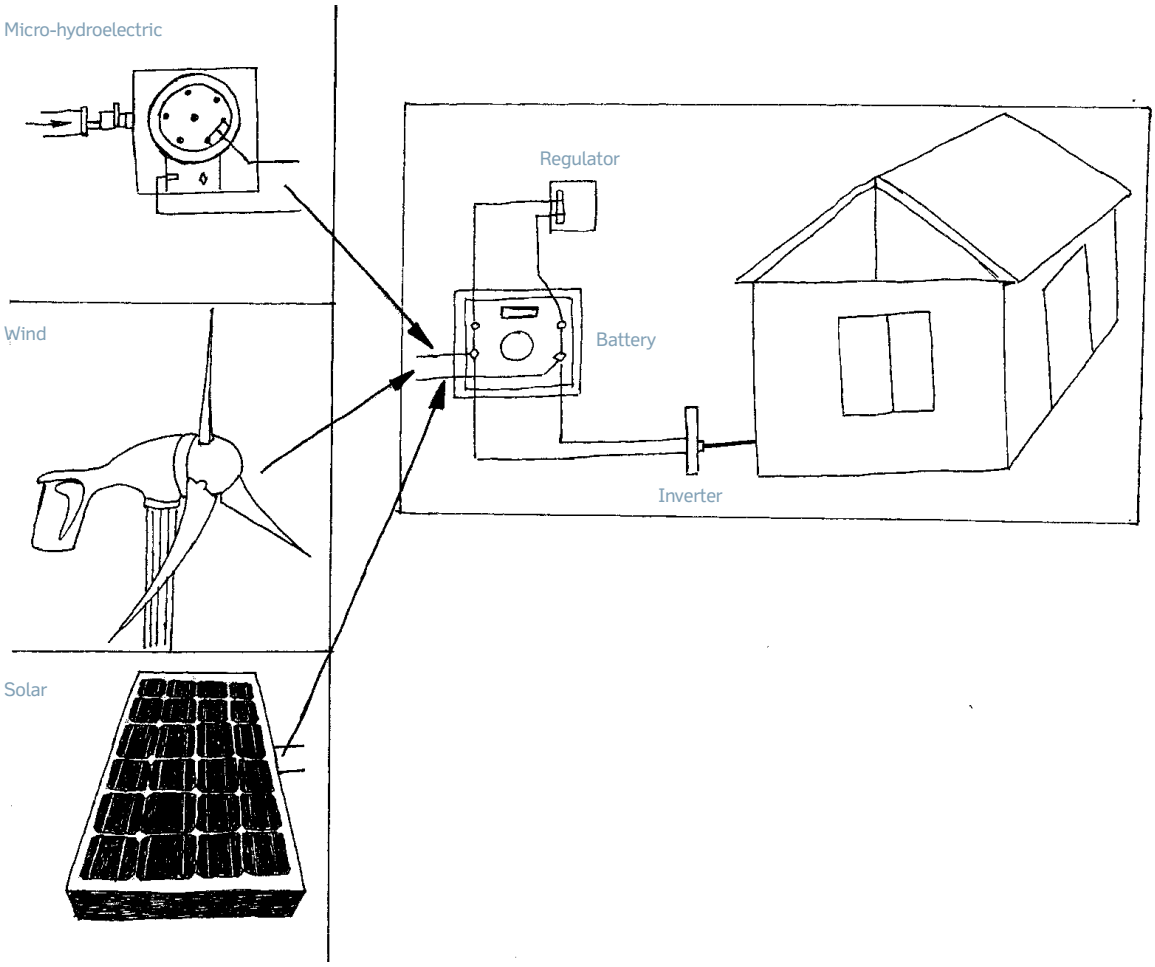
All levels of the population – individual households, communities, businesses, regions and nations – must change how they use their resources, including electricity generation.

At household and community level, use:

- Solar panels and solar hot water
- Small wind turbines
- Micro-hydroelectric systems
- Biogas (anaerobic digestors)

These systems cost money to set up, but once they are running the energy that comes from them is free! Good maintenance and effective repairs are important to ensure the system has a long life. Over time the money spent on buying a renewable system is much less than the continual cost of paying for electricity and fuel. Renewable energy sources are quickly becoming more popular which makes them cheaper and longer lasting.

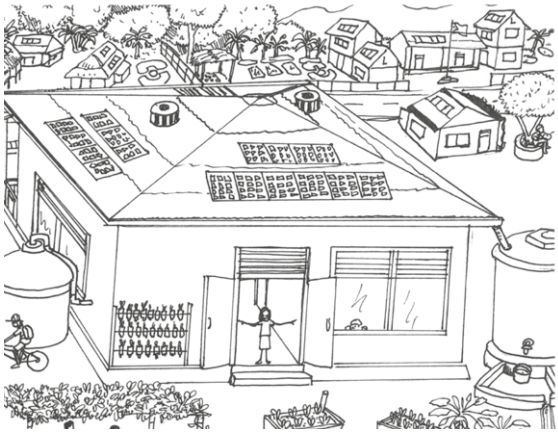
Natural energy sources and system



Renewable energy sources on a regional, business and national level include:

- Solar farms and solar thermal systems
- Large wind turbines
- Biogas from city waste dumps and other large-scale sources
- Micro-hydro and hydroelectric systems
- Geothermal generation
- Tidal ocean energy

Technology is developing very quickly for large-scale renewable energy systems. Businesses and governments must be encouraged to invest in these systems to protect their populations for the increasing impacts of climate change.



Solar system on a community building

We have not included uranium or nuclear energy as a solution because:

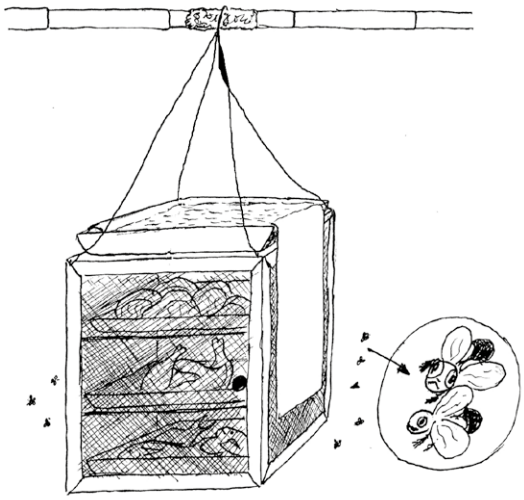
- It is a non-renewable energy source.
- It has too many very dangerous and very expensive long-term consequences, from mining, transporting and using the uranium, to managing the power plants after they have shut down and storing the waste that is created.
- The power plants take an enormous amount of time, money and energy to build and maintain.
- It is not an energy source that is capable of reducing the impacts of climate change in the time that we have available.

MINIMISING ENERGY USE

It is very important for people all over the world to use less electricity, even if it comes from renewable sources.

There are many ways to minimise electricity use:

- Having a good house design allows sunlight inside, decreasing the need for artificial light; it creates good ventilation and air flow, keeping houses cool in the heat and warm during cold nights so there is less need for electric fans.
- Turn lights, fans, television, etc. off when you are not using them.
- Low watt LED light bulbs.
- Minimise air conditioner use.
- Natural methods for keeping food cool reduce the use of refrigerators.



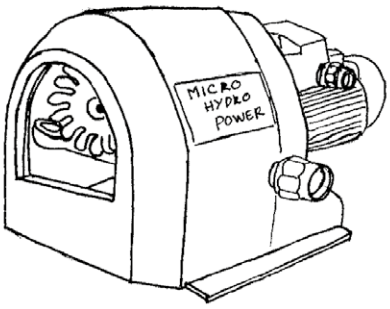
A Coolgardie Safe keeps food cool and prevents flies and insects from spoiling it

Types of renewable energy

The systems we explain show some of the options for households and communities. The information we provide is only an introduction; look in the reference chapter for websites with detailed information about these technologies and for large-scale renewable energy options.

HYDROELECTRIC SYSTEMS

Hydroelectric systems use flowing water to create electricity. The water from a river, dam or lake is run through a pipe that goes downhill, creating a fast continuous water flow. The water flow makes a wheel spin inside the hydroelectric unit, which then turns a turbine to create electricity. This electricity is stored in batteries, ready for use.



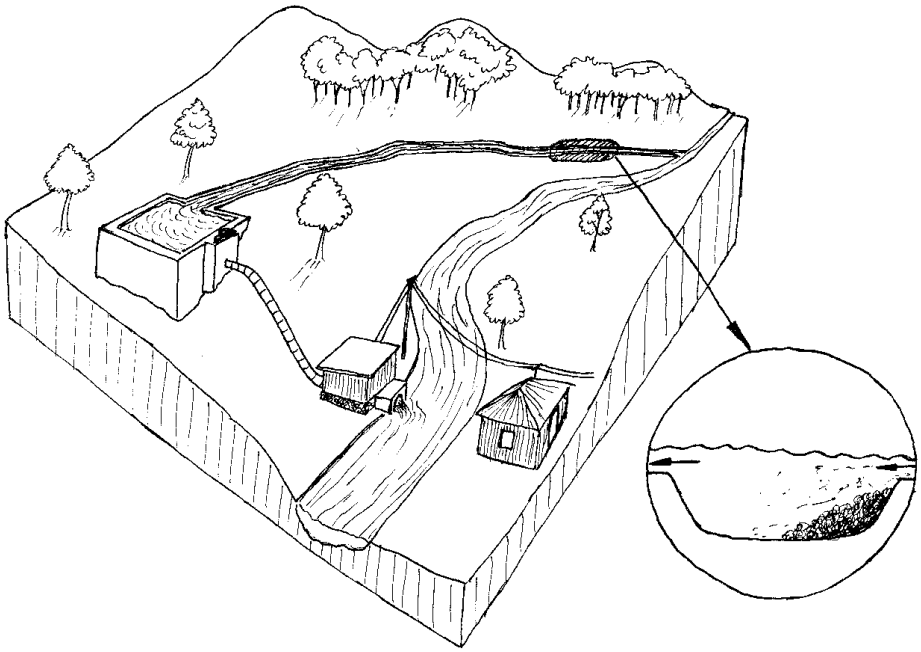
Micro-hydroelectric turbine

Hydroelectric systems can be different sizes:

- Micro-hydroelectric systems provide electricity to a few houses or a village.
- A bigger system supplies electricity to a town or wider area.
- Large hydroelectric systems built near a lake or large dam provide electricity for an area with many towns or cities.

Micro-hydroelectric systems are excellent because:

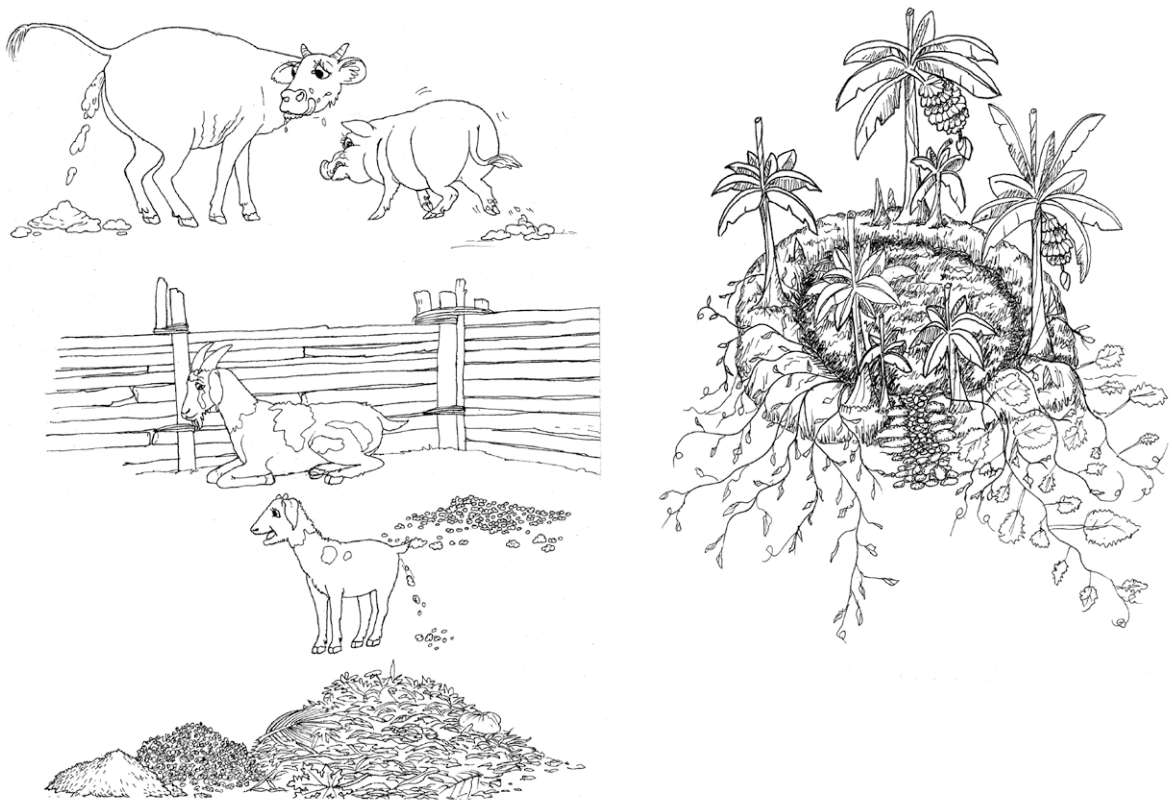
- They generate a continuous supply of electricity.
- They are MUCH better for the environment than bigger hydroelectric systems, both to set them up and their long-term impact.
- They require much less maintenance than bigger hydroelectric systems.
- They need a much smaller number of storage batteries and require less maintenance than solar systems.


Micro-hydroelectric system for a small village

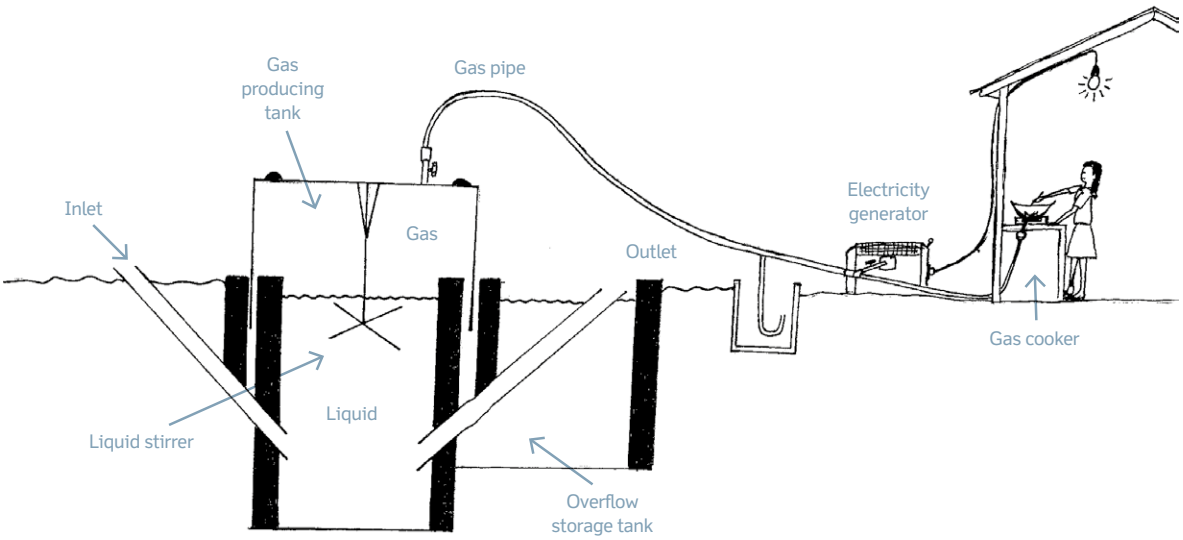
BIOGAS SYSTEMS

Biogas systems (also known as anaerobic digesters) are a very important renewable energy technology, especially for remote areas. They harvest and store energy from waste and create high-quality fertiliser at the same time.

A biogas system collects methane, a flammable gas that people can to cook with, use for gas lights, run internal combustion engines and make electricity. Methane gas is made naturally when animal and human manure, rice and coffee husks, leaves, water plants and grass decompose.



In a biogas system these materials are placed in a biogas tank to decompose. The methane gas is then trapped in the tank and collected for use. If new materials are constantly added to the tank, the gas is continually produced for collection. Regularly remove the old materials from the tank to use as high-quality fertiliser.



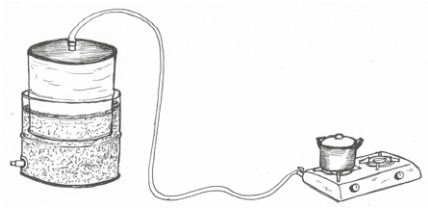
There are many benefits:

- Gas and electricity are produced from free or cheap resources.
- The gas replaces the need for firewood and does not produce polluting smoke.
- The manure and other materials keep all of their nutrients. In fact, through the gas-producing process, plants use the nutrients more easily and the micro-organism levels increase. Once the decomposing materials have finished producing methane gas they can make compost, liquid compost or applied directly as fertiliser – be careful though because it is strong, so dilute it with water first.
- Almost all the illness-producing bacteria in the manure are killed in the biogas tank. The process also kills most parasites such as human and animal worms.
- Methane gas from manure and rotting leaves is stored and used instead of contributing to climate change.

What you do with the manure/plants when they are finished producing gas depends on what type of manure is used. Animal manure can be applied straight away as diluted fertiliser or composted, but human manure must be put through a slow compost system first to make sure all the pathogens are removed.

Biogas systems can provide energy for one house or many houses. The technique is used in many countries and is excellent, especially for remote areas.

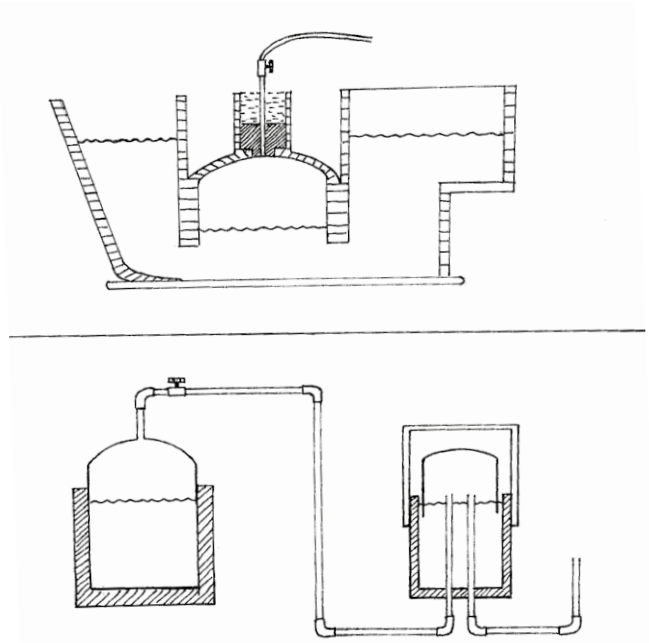
There are many different designs and sizes, depending on the type of manure, money and building materials available. They can range from a simple 44 gallon drum, to a cement chamber through to large-scale systems.



A small simple biogas collector using metal drums.

Some basic facts about a biogas system:

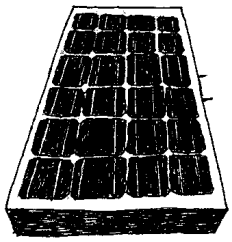
- 1 m3(1 m x 1 m x 1 m) of methane gas provides:
  - Gas to cook three family meals OR
  - Six hours of light from a light bulb OR
  - 700 ml of petrol OR
  - Run a two-horsepower generator for two hours OR
  - 1.25 kw of electricity
- A tank about 1.5 m3 per person provides enough methane gas: e.g. 15 m3 for 10 people
- A biogas system is anaerobic (so does not need oxygen) and must be made both airtight and watertight.
- Regular maintenance is important – you need to manage the water and PH (acid or alkaline) levels, temperature, material input mixtures, harmful materials and stir the tank regularly.



Different biogas system designs

Creating and maintaining a biogas system needs research and technical knowledge. This brings better skills and knowledge to a community, as well as the many benefits from the biogas system. It also promotes self-reliance. Read the reference chapter for more information.

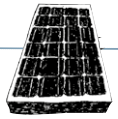
SOLAR SYSTEMS



A solar system uses light from the sun to create electricity through solar panels (made up of photovoltaic cells). A charge controller (regulator) controls the electricity flow and the electricity is then stored in large batteries. The electricity can power lights, a radio, recharge mobile phones and other needs. Solar panels must be placed in direct sunlight, not shaded by trees, buildings, etc.

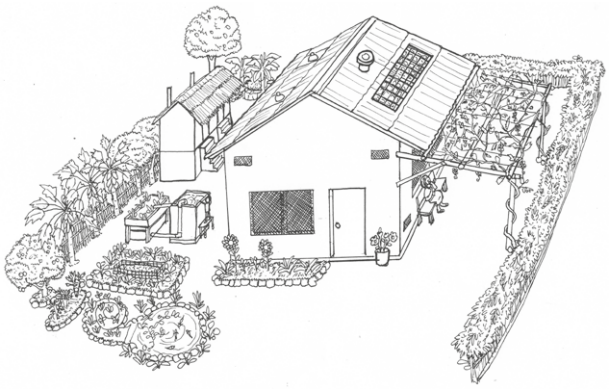
The solar panels can be set up anywhere and are great for remote areas. Knowledge of how to maintain and use them properly, including maintenance training, a repair kit and information booklet, is essential. The batteries must be particularly well looked after or they will stop working very quickly and become useless.

Solar energy technology is progressing very quickly. Panels are getting cheaper and more powerful all the time, and battery technology is also improving fast. In the near future you will be able to stick plastic panels on your walls or paint your walls with solar-panel paint!



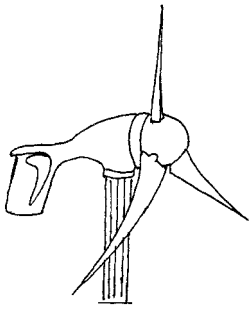
SMART IDEAS:

- If the solar panels get too hot they do not work as well. This happens when they touch metal or tin roofs. Raise them away from tin roofs or put lots of insulation (old material, cardboard, bamboo, wood, etc.) between the roof and the panel.
- An inverter box regulates the flow of electricity from the batteries to lights, fans, radio, TV, etc. They are expensive, but they improve the electricity supply and the life of the electrical equipment.
- It is important to ground the solar system correctly, especially in areas where there are a lot of electrical storms: just one lightning strike could seriously damage the equipment or even start a fire.



House with a solar panel system

WIND SYSTEMS



Wind is constant in many places making it very reliable for generating electricity. A wind generator uses a propeller (similar to one found on a helicopter) that turns when the wind blows. The movement of the blades causes a shaft to turn. A series of gears then turn which transmits energy to a water pump or generator. The energy created is stored in large batteries which provide electricity.

Wind generators can be small, providing electricity for a house, or very large, creating electricity for a village.

In many countries businesses are setting up wind farms consisting of many large wind generators in areas with strong winds to create a lot of electricity. This electricity is part of the power supply for nearby cities and towns.

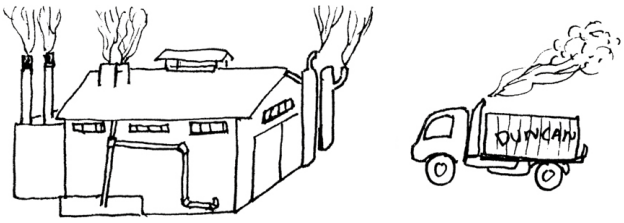
To power houses or communities small-scale solar, micro-hydroelectric or biogas systems are usually cheaper and better, although new cheaper small-scale wind systems are currently being developed. Wind energy is great for windy and drier areas.

In the future, wind farms will provide electricity for towns on a large scale, replacing diesel generators. This requires government and businesses to work together. Wind farms cost a lot to build, but the gains from not having to buy and transport expensive fuel and maintain generators mean that they are cost effective in the long term. They can be part of a national system and combined with hydroelectric, solar and other renewable electricity sources.

Transport and transport fuels

Vehicles (cars, buses, trucks, etc.) create a lot of the global pollution problems today. This is from the pollution created:

- By mining, refining and transporting the oil and petrol for vehicles, as well as the environmental damage from the extraction process, especially with large-scale oil spills on land and at sea.
- When the vehicles burn the oil and petrol
- From manufacturing the vehicles

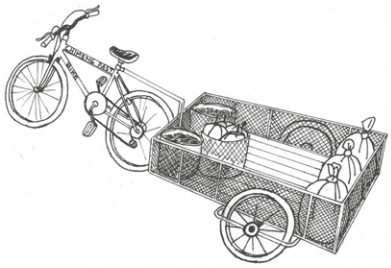


Factories now produce electric cars that run on electricity, or a mix of electricity and petrol (called hybrid cars). These are far more sustainable because the electricity that charges the cars can come from renewable energy. Electric cars have been expensive but, like solar panels and wind systems, are becoming cheaper and will be more common in five to ten years.

Science-driven research and development are creating and refining new technologies to reduce the world's dependency on fossil fuels. The world's first biogas fuelled bus is now running in England, the first of many!

To decrease pollution and reduce climate change problems, all governments and businesses must encourage, build and use more public transport systems such as buses and trains. People must demand this commitment and investment from their governments.

"Burn fat, not fuel!" This is a growing global public campaign to encourage people to ride a bicycle, not drive a car. Many people have forgotten bicycles are also a form of transport in the race for the status attached to riding a motor bike or driving a car, but they are cheap and good exercise too. They are great for many daily tasks, especially in urban and traffic-congested areas where they are often the quickest way to travel, and there are many different bicycle attachments for transporting food, goods and children too. Bicycles are THE new cool status!



COCONUT OIL FOR DIESEL CARS AND DIESEL ENGINES

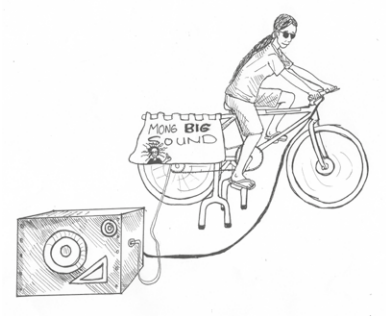
Coconut oil is simple and appropriate for most tropical countries, and is already used in New Guinea, Fiji and Thailand. It can fuel all diesel engines, including hand tractors, rice mills, small generators, pumps, etc. It could be used for cars and trucks but that would be too expensive for most people and take too much oil from food consumption. It MUST be very high quality coconut oil or it destroys the engine. Coconut oil from the markets cannot be used.

To use it mix 20 parts coconut oil to 1 part kerosene (5%). This helps to make it thinner. In cold areas, mix 10 parts coconut oil to 1 part kerosene (10%).

With small changes and an oil heater cars can also run on used cooking oil from restaurants! Research this and other technologies in books and on the internet.

Other energy technologies

Anything that can spin a turbine can create electricity. There are more and more creative ideas turning into new inventions. One of the easiest methods is using a bicycle.



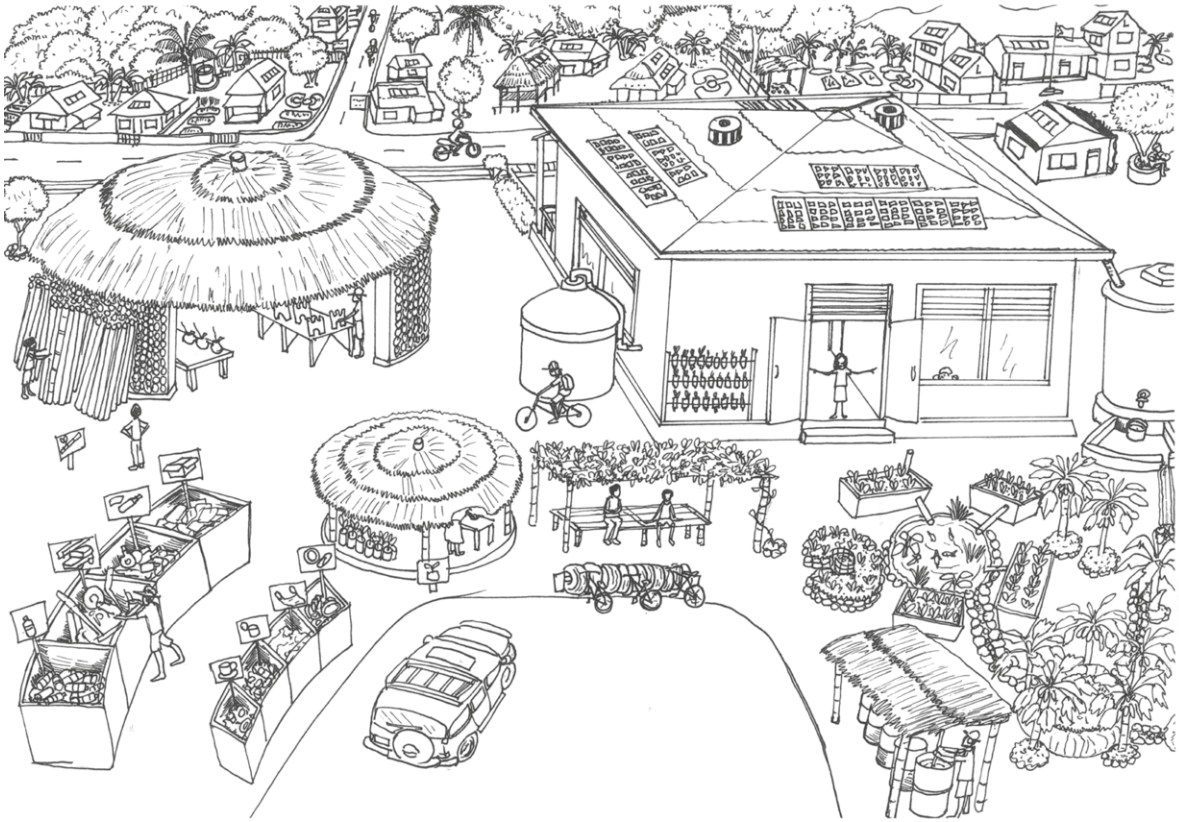
Bicycle powered sound system

Wind-up devices are becoming more common, where a battery to run a device is charged using a wind-up handle or lever. Torches, radios and laptops are three examples, and as the batteries and technologies develop there will be a lot more.

There are also many devices with small solar cells that charge batteries.

A Continual Process

Improving your house, water and energy supply is a continual process of observation and action. Look out for new techniques, technologies and strategies to include, add more beauty, save more time, use less energy and work towards achieving a more comfortable and resource-secure life. As a household the benefits are many, as a community they are multiplied many times – think of what we can do globally!



HOUSES, WATER AND ENERGY
CHAPTER NOTES

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8. FOOD, HEALTH AND NUTRITION

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Good health starts with understanding good nutrition and eating local, natural foods grown in good organic soil. When food is stored well it keeps fresh much longer. When it is dried or preserved it is available all year. When it is cooked using stoves and ovens the environment benefits and kitchens are healthier. Everything we can do to improve our health and prevent sickness will improve our lives and benefit our families and communities.

Good food from good agriculture

Good food is good health, and good food comes from good soil. There is a direct link between the amount of nutrients in the soil, the ability of the plants to take them up, and the amount of vitamins and minerals in the food we eat.

This means **soil quality relates directly to good nutrition** – better quality soil means better quality produce with more nutrients. And they taste better too! This is the best and most direct way of improving health. Improved health means fewer visits to the doctor, better concentration, more strength and energy, and a longer life. Good quality food also fills people up more when they eat and keeps them feeling full for longer.

Good soil quality is very important for all types of food production, even for the soil that grows food for animals. Their health improves from having more nutritious food, and their meat is better quality too.

Women, who do most of the cooking, home gardening and educating about nutrition, also need to learn and understand more about soil quality, soil science and techniques to improve the soil. The techniques are simple, do not require heavy work and use local materials. See Soils (**Ch 9**) for more details.

BE CAREFUL: Plants absorb the chemicals that are sprayed on them. Some of the chemicals can be washed off fruit and vegetables, but some are absorbed through the skin and stay in the food. This is especially a problem when food is harvested less than two weeks after the last chemical spray, and this happens a lot! The pesticides, herbicides and fungicides are bad for our health and build up in people's bodies over time, creating more health problems later in life.

Food that is stored for a long time loses a lot of its nutritional value, especially fruit and vegetables. Picking and eating fruit and vegetables straight away makes a big difference to the amount of vitamins and minerals in the food.

Food that is processed and packaged often has very little nutritional benefit and lots of added sugar, unhealthy oils and salt.

All over the world people are beginning to realise there are links between what we eat and our health, and the answer is the same everywhere:

Eat organic, eat fresh and eat local!!

Traditional cooking

Good food, good nutrition and good health are directly related to traditional cooking.

Major changes in diet and food production systems have affected traditional and healthy eating patterns in every tropical country. This leads to serious health problems including diabetes, obesity and malnutrition. It can also lead to starvation, a widening social gap and environmental degradation.

Maintaining traditional cooking styles usually happens when culture is strong, and helps to keep it strong.

Traditional cooking uses whole food, which means food straight from where it was grown – fresh, cooked, dried or preserved, both locally produced and based on seasonal harvests. This is the basis for good health.

There are about 7,000 edible plant species in the world, but over 50% of our daily calories come from only three species: rice, wheat and maize. This shows how much food we are missing out on.

Good nutrition

People, especially children, need to eat a wide variety of food to meet their nutritional and calorie needs, and to be healthy and strong. **This means eating many different types of vegetables, fruit, grains and roots, eggs, meat, seeds, nuts and beans. A wide range of healthy organic vegetables grown at home provides many vitamins, minerals, proteins, energy and oils. A good variety every day is best, but sometimes it is easier to think about maintaining a healthy diet over a week rather than each day.**

The most important time for good nutrition is when women are pregnant, and for new mothers and babies. Other family members need to make sure that mothers and babies are eating as well as possible. This reduces the chances of babies becoming sick and leads to better health in later life.

Good nutrition leads to:

- Fewer health problems
- Faster recovery after sickness
- Children growing up stronger and healthier with fewer health problems as adults
- People living longer
- More energy for work and play, therefore, more can be achieved in a day
- An increase in the ability to learn and concentrate, which is very important for children at school. Better food leads to smarter people.

SMART IDEAS:

- Changing your habits: We all have different eating habits; sometimes they are from necessity, sometimes from choice. Sometimes these habits do not lead to a healthy diet, and sometimes they can make you sick. It only takes a few weeks to get your body used to new, healthier eating habits and, once this happens, your body then depends on the new habits.
- Eating local, healthy food not only leads to better nutrition, it reduces packaging, transport, refrigeration and food waste. As a result, it decreases negative impacts on the environment. However, DO NOT accept plastic bags at the markets; they are unnecessary and create pollution.
- Growing a wide variety of food also makes agricultural land much more productive and sustainable.
  Good for you = good for your environment!

The good nutrition circle

This chapter explains how to provide good nutrition all year round from local and traditional sources.

Good sources of nutrition

Eating food fresh and uncooked retains all the vitamins and medicinal benefits.

When you boil food, always keep the water used for soups, sauces, curries etc. Throwing away the cooking water means that many vitamins are lost. Organic food and food from good soil contains many more vitamins and minerals.

See the following list for which vitamins and minerals are in what food:

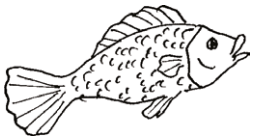
VITAMIN A (FOR EYES)

Leaves from taro, sweet potato, cassava and pumpkin, and pumpkins, cabbages, green leafy vegetables, carrots, ripe mangos, bananas, ripe papayas, moringa, sweet leaf, bitter melons, watercress.

VITAMIN C (FOR DAILY HEALTH)

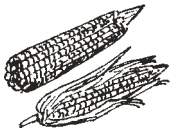
Green papayas, lemons, oranges, mandarins, pomelos, custard apples, soursop, sweet peppers, tomatoes, pineapples, rambutan, guavas, mangos, cashew fruit, tamarind, moringa, sweet leaf.

PROTEIN (FOR STRONG BONES AND MUSCLES)



Eggs, fish, meat, peanuts, all beans, peas, pigeon peas, watermelon seeds, banana tubers, sesame seeds, sunflower seeds, cashew nuts, candle nuts, moringa seed pods, Sesbania grandiflora (hummingbird tree) seed pods, sprouted seeds, moringa leaf, sweet leaf, tempeh, tofu, insects.

ENERGY (FUEL FOR PEOPLE!)



Corn, sweet potatoes, cassava roots, canna roots, taro, yams, jicama, yacon, potatoes, rice, pumpkins, avocados, ripe coconuts, jackfruit, breadfruit, bananas, sugarcane.

FATS AND OILS (FOR HEALTHY INSIDES)

Coconuts, avocados, peanuts, candle nuts, cashew nuts, soybeans, sesame seeds, sunflower seeds, milk, butter, cheese, fish.

IRON (FOR STRENGTH AND STAMINA)

Mustard, amaranth, green leafy vegetables, banana hearts (banana flowers), cassava leaves, sweet potato leaves, dried beans, moringa, sweet leaf, meat, eggs.

All vegetables, including ones not listed above, such as eggplant, choko (chayote), okra, cucumbers, onions and radishes, and fruit - watermelons and passion fruit - also provide many vitamins and minerals. Fresh green vegetables daily provide great nutrition as well as helping your digestive system function well.

BAMBOO SHOOTS

Provide many different vitamins, minerals, amino acids and proteins.
Read Bamboo (**Ch 16**) for how to cook bamboo shoots.

PEAS AND BEANS

Provide proteins, vitamins and minerals. They are easy to grow and excellent to dry and store, especially pigeon peas.

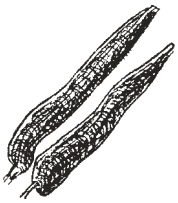
MUSHROOMS

Are another excellent food for good health, providing proteins and many vitamins and minerals. You can collect them wild, and by using manure, liquid compost and mulch you can encourage them to grow in gardens and vegetable plots. This is because mushroom spores (seeds) live in and are spread by using manure, compost and mulch. Read more about growing mushrooms in Family gardens (**Ch 10**) and Sustainable agriculture (**Ch 13**).

TEMPEH

Tempeh is a great food and, because it is fermented, it has good bacteria for your digestive system.
It is higher in vitamins and protein than non-fermented soy beans. (See fermented foods below.)
It is mostly made from soybeans, but it can also be made from chickpeas and other beans.

CASSAVA ROOT



Cassava root (also known as tapioca, yucca or manioc) is an important energy food for people in most tropical countries, especially because it grows well in difficult conditions. It must be prepared properly, using traditional methods (squeezing out the juice and cooking at high temperatures), to avoid becoming sick from the bitter poison cassava roots contain in small quantities. It is important to select and breed the less bitter cassava variety.

SPROUTED SEEDS

Sprouted seeds (often just called sprouts) are an excellent source of vitamins, minerals and proteins. Sprouts are seeds that have started to grow. They are eaten three to five days after the first growth, before the first true leaves develop and the roots grow more than one or two shoots. When seeds sprout their nutritional value and protein levels increase a lot. Mung beans are the most common seeds for sprouting in the tropics, but you can try other beans, peas and some vegetables.

Method:

- Soak the seeds in water overnight.
- Drain the seeds for at least five minutes, until all the water is removed.
- Rinse the sprouting seeds with fresh water once a day if they are dry.
- Eat the sprouts immediately or store in a refrigerator when they are ready.

In the dry season rinsing the sprouts is usually required, however in the rainy season rinsing with water can make them go mouldy. Good drainage is important, especially in the rainy season. Using filtered water for growing sprouts is highly recommended to prevent the spread of bacteria and disease. Look in the reference chapter for more information.

With good organic techniques and care you can produce high quality and nutritious vegetables, fruit, meat, eggs, herbs, spices and medicines at low cost, therefore producing enough to sell AND eat at home. You can also exchange excess produce for other goods or food.

Good drinks

Healthy drinks and lots of water are important for good nutrition, especially after physical work. Avoid drinks with lots of sugar because they cause many health and dental problems, and avoid adding sugar to drinks.

If you need to sweeten a drink, use honey, fruit syrup or stevia (a plant used as a natural sweetener which grows very well in tropical conditions). Healthy drinks include:

- Water – drink a lot every day!
- Coconut water – great for rehydration and minerals
- Natural fruit and vegetable juices – lots of natural sugar, vitamins and minerals
- Natural smoothies and lassies – nutritious and tasty
- Tea and coffee – drink in moderation as they are stimulants
- Herb teas – different teas have different properties, and many are natural medicines
- Lime and lemon juice – refreshing, cleansing and high in vitamin C

Food as medicine

All organic whole food is good medicine if it is eaten in a balanced diet. It keeps the body clean and functioning well without adding any toxins.

A very important part of our body for good health is our digestive system. Scientific research shows that when our digestive system is healthy it helps improve general physical and mental health, as well as preventing many diseases including diabetes, allergies, stomach and bowel problems and some cancers. **The best way to have a healthy digestive system is to eat whole food.** Whole food is food sourced directly from where it was produced, unprocessed and natural, and eaten fresh, either raw or cooked.

Many foods help to reduce or cure some sicknesses, and many others help to prevent sickness:

BITTER FOOD

Bitter food is a very important part of a healthy diet. Examples are bitter melons, bitter gourds, the leaves and flowers of papaya, green papaya fruit, passion fruit leaves, water cress, banana hearts, gotu kola, parsley, Thai eggplant, neem, endive and kale. Bitter foods:

- Help the body absorb nutrients
- Cleanse the body, helping the liver's function of removing toxins
- Boost the immune system
- Stimulate metabolism
- Help reduce sweet food cravings

Papaya leaf

LEAVES HIGH IN PROTEINS, VITAMINS AND MINERALS

Leaves high in proteins, vitamins and minerals can be dried and powdered. The powder is best stored in airtight containers or capsules. Moringa, sweet leaf, comfrey and Sesbania grandiflora (hummingbird tree) are examples. A teaspoon or two of leaf powder each day can make a big difference to health, like taking a vitamin tablet but better.

JICAMA AND YACON ROOTS

Jicama and yacon roots are tasty, sweet root vegetables. They can be eaten raw or cooked and have a type of sugar that reduces the chance of diabetes.

GOTU KOLA

Gotu kola is a great bitter food which helps by cleansing the body and blood, and improving concentration and memory. Mix it with shredded coconut and lime to make a tasty Sri Lankan salad.

NEEM

Neem is a bitter food which helps with some skin conditions and reduces the risk of diabetes.

COCONUT MEAT, MILK, WATER AND OIL

Coconut meat, milk, water and oil all contain proteins, vitamins, amino acids and minerals as well as having many other health benefits.

SPICES AND HERBS

Ginger

Spices and herbs, such as turmeric, chili, ginger, garlic, pepper, coriander and basil, are very tasty, but also important for healthy bodies. They help fight some sicknesses and remove infections.

OTHER HERBAL MEDICINE

Aloe vera

Other herbal medicine, especially small medicinal plants, such as aloe vera and mint, can also be grown close to the house with flowers and vegetables.

TRADITIONAL PLANTS AND LEAVES

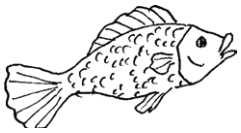
Purslane

There are often **traditional plants and leaves,** such as purslane, that have a high nutritional content and other medicinal benefits when a few leaves are added to salads, soups and other foods.

SEAWEED

Seaweed is a great source of vitamins, minerals and trace elements, and an important food for coastal communities that provides many health benefits.

FISH AND ANIMAL BONES

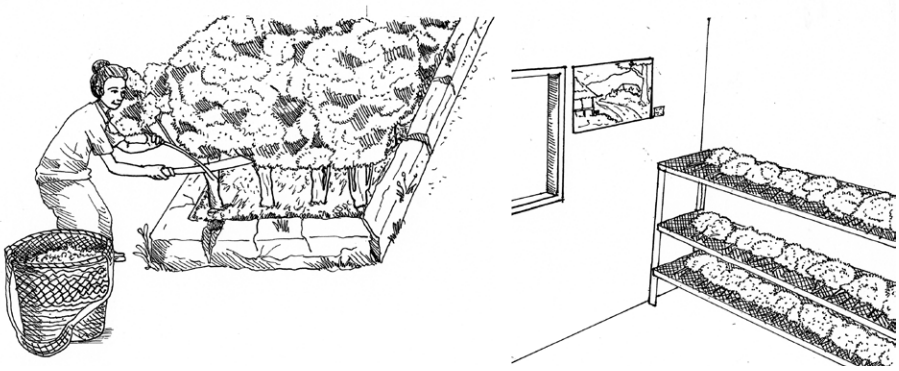


Fish and animal bones are good sources of sodium, calcium and phosphorus, and can be dried and powdered for use as an important nutritional supplement. If they are used to make soup stock (do not over-boil), they provide nutrition and are a health tonic for some sicknesses.

DRYING MORINGA LEAVES

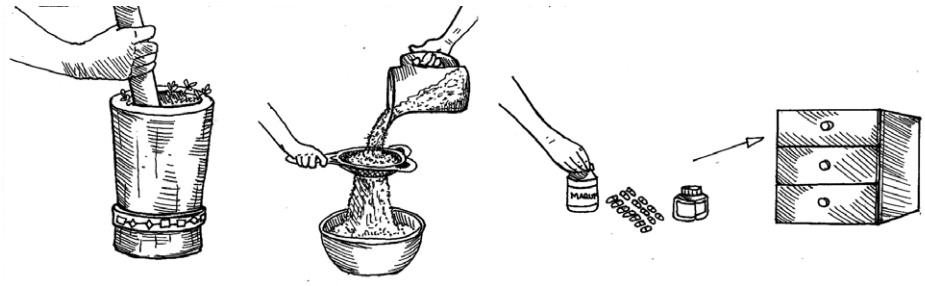
Here is the process for drying moringa leaves:

- Harvest when the leaves have no moisture on them, and do not take more than 25% of the tree at a time.
- Remove any yellow or old leaves.
- Always dry in the shade or inside, free from animals and insects.
- Dry on wire, old mosquito netting, old fishing nets or slatted bamboo, as air flow is essential.
- If the leaves take longer than two days to dry, the process is not working properly.


Cutting and drying moringa leaf

- Leaves are dry when they are crunchy.
- Turn the dry leaves into powder by using a mortar and pestle or blender.
- Use a strainer to separate the powder from leaf remains.
- Put the powder into small airtight containers, small sealable plastic bags or capsules. Small is important because nutrients are lost through opening the containers and exposing the powder to oxygen.
- Leaf remains are good for making tea or feeding to animals.
- Store the dried moringa in a cool dark place.
- Always use within six months.

You can use the same process to dry other leaves, but drying times may vary.



Turning the moringa leaves into powder then storing it properly

FERMENTED FOOD

Fermentation occurs naturally. For thousands of years humans have learnt how to use fermentation to create new food sources as well as to preserve food for later consumption. There are many examples in every culture. Fermentation is the conversion of sugars and other carbohydrates into preservative organic acids, for instance, converting sugars in vegetables to preserve them, juice into wine, grains into beer and carbohydrates into carbon dioxide to make bread rise.

It is now proven that fermentation also provides many health benefits:

- Fermented food is easier to digest.
- Fresh food can be preserved in bulk for later consumption.
- Food is biologically enriched with proteins, essential amino acids, and vitamins.
- Beneficial micro-organisms improve the digestive system and stomach health.
- The diet is more diverse through developing different flavours, aromas and textures.
- It eliminates anti-nutrients which prevent the body from absorbing and using nutrients.
- There is a decrease in cooking time and the amount of cooking fuel needed.

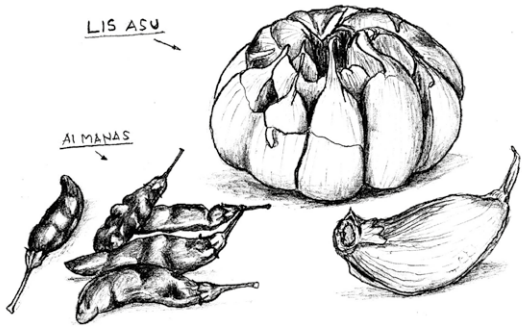
Fermented food includes pickled vegetables, tempeh, natural vinegar, pastes and many more.

NATURAL MEDICINE

There are many cultures which have knowledge of traditional medicine from plants. This knowledge must be kept and shared so people can continue to treat health problems by growing and using medicinal plants. **Please note:** we recommend going to the doctor when necessary, but there are many forms of preventative and curative natural medicine that can complement western medicine and provide good health outcomes for all people of all incomes.

Some examples of plants and natural health products are:

- Natural mosquito repellants: turmeric, basil, citronella, lemon grass, tea tree leaf oil, *Leptosermum petersonii* leaf oil (lemon-scented tea tree) and many more
- Wormwood (*Artemisia absinthium*) for treating malaria and other ailments, but it is also highly poisonous if not used properly
- Neem-based products
- Turmeric-based medicines
- Skin products, such as candle nut and coconut oil
- Natural soaps
- Muscle/joint pain relief and massage oils
- Treatments for coughs and tight chest relief
- Cures for blocked sinuses and noses
- General health tonics



For local natural medicine there may be opportunities for developing products, but they must be very well tested before sale.

KITCHEN AND BATHROOM CLEANERS

Vinegar and citrus cleaner is a strong and simple cleaner for kitchens, floors and bathrooms. Add citrus peel to a large container (2–5 litres) that is half full of vinegar. Keep adding the peel until it is completely full and leave for one month. Strain the liquid and discard the peel. Use the liquid straight as a strong disinfectant or add 50 ml per one litre water for cleaning large areas.

Cloves/clove oil kills mould. Bleach does not kill mould – it only changes the colour. Add 1/2–1 ml of clove oil to your liquid solution when washing mouldy objects.

Soapnuts or soapberries (from the Sapindus genus of trees) are a natural and effective way of washing clothes.

Bad nutrition

Our modern diets are often not healthy at all, and are the primary causes of many sicknesses.

Much of the mass-produced food and drink available tastes good, but only because it is full of excess salt, sugar, oil and flavour enhancers. Even worse, this food has little or no nutritional value and is supplied on demand instead of being seasonally available. Non-organic food often contains chemicals that our bodies have to work hard to remove or they stay there, often causing sickness. The further we get from eating whole and organic food, the more damage we do to our bodies. The occasional treat is not bad, but too often people eat too much processed food.

To put it simply, highly processed food and drink are burdens and often toxins that your body has to remove rather than food or drink your body can use.

- Sugar in large amounts causes weight problems, diabetes, an unhealthy digestive system, bad teeth and generally poor health. It is in most processed food and even "natural" packaged food contains a lot more sugar than you think. Always check the ingredients on the packet. The worst for high sugar levels are carbonated drinks. Honey and stevia are great sweetening alternatives.
- Highly processed food is made from artificial ingredients and is chemically engineered. Excess amounts of sugar, salt, oil and flavour enhancers have little or no nutritional value. This means that you do not gain anything from eating it, and it makes your body suffer and eventually get sick.
- Fast food is very common in western countries, causing massive health problems and is becoming much more common in tropical countries too. Most food is highly processed; even the bread has lots of sugar in it!
- Palm oil and cooked oils are in many products. It is not only unhealthy for humans but very unhealthy for the environment, with palm oil plantations responsible for huge areas of land being deforested and cleared. Cooked oil becomes chemically fractured after many uses and is not healthy at all.
- Margarine is a common substitute for butter, and it is highly processed. At the end of the manufacturing process, lots of yellow food colouring is needed to make margarine look appetising. The chemical composition is fractured, and your body finds it very difficult to digest and remove.
- Diets mostly do not work. It is much better to change eating habits than go on short diets. Understanding nutrition and how to get what you need from whole food is the key. One diet worth following is a colour diet. If you eat lots of different coloured natural foods each day, you probably eat well!

Good nutrition and good habits start at a young age. Encourage children to eat fresh fruit instead of sugar snacks, and provide whole instead of processed food.

Important plants to grow around your house

This list describes 20 very useful plants that are easy to grow around the house and provide important nutritional and health benefits all year.

There are many more food and medicine plants local to your area that can be included as well. Seaweed is another important food for good health but is usually only readily available for those who live on the coast.

In some western cultures much of this food is now called "Super Food" and is considered very 'new and trendy'. However, the plants are just being rediscovered as they have been well known and used in traditional cultures for hundreds, sometimes thousands of years!

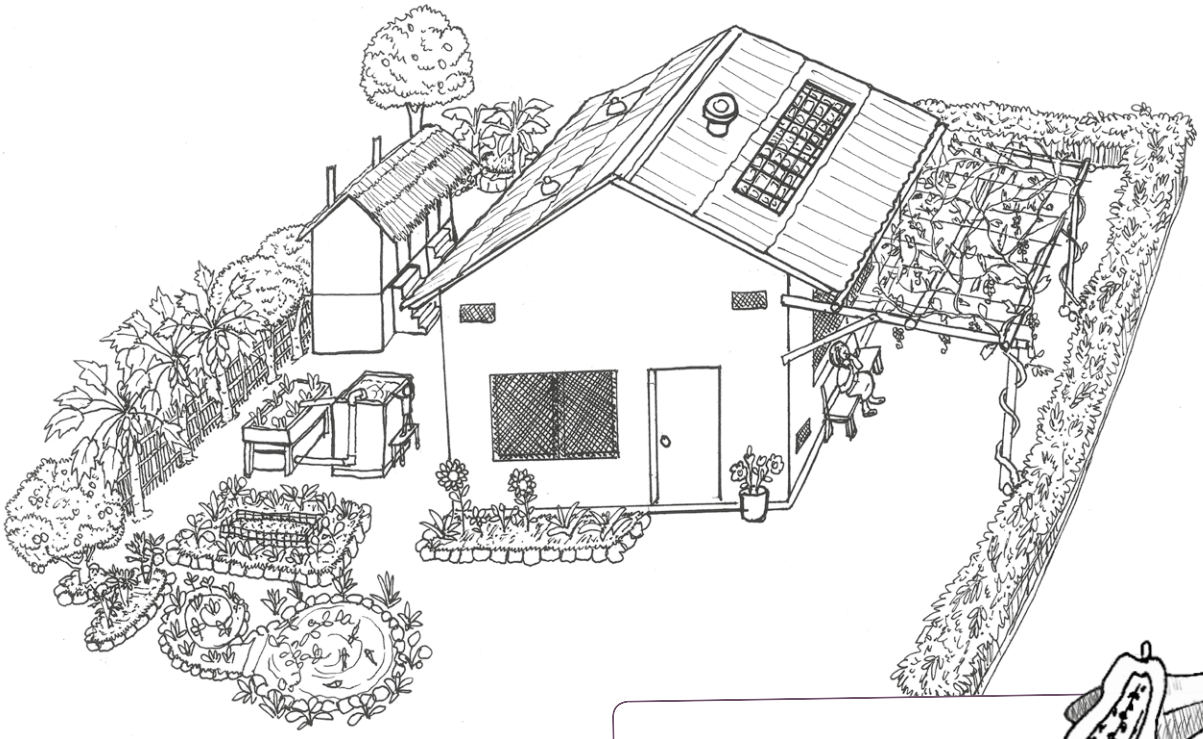
IMPORTANT PLANTS FOR AROUND THE HOUSE

Plant	Benefits	Growing habits
Moringa	• all year supply • very high in proteins, vitamins and minerals • can eat leaves fresh or dried and young seed pods	• grown from seeds or propagation by cuttings • medium sized tree • prefers sandy soils • dry and drought tolerant • can be regularly pruned • grows very well up to 500 metres above sea level
Sweet leaf	• all year supply • very high in proteins, vitamins and minerals • great for salads or can be cooked	• grown from propagation by cuttings • perennial bush • can be regularly pruned to make a hedge • dry and drought tolerant • grows in sun or part shade
Amaranth	• very high in proteins, vitamins and minerals	• grown from seeds • fast growing • planted all year but especially in the wet season
Tree spinach	• all year supply • high in proteins, vitamins and minerals	• grown from propagation by cuttings • grows in sun or part shade
Water spinach	• all year supply • high in proteins, vitamins and minerals	• grown from seeds or propagation by cuttings • good for wet areas and ponds • easy to grow
Water cress	• all year supply • high in proteins, vitamins and minerals	• grown from seeds or propagation • good for wet areas and ponds • easy to grow
Kale	• high in proteins, vitamins and minerals • bitter vegetable providing many health benefits	• grown from seeds and propagation by cuttings • dry season only • especially good for mountain areas

IMPORTANT PLANTS FOR AROUND THE HOUSE		
Plant	Benefits	Growing habits
Comfrey	• very high vitamins and minerals (best used in tea or tonic) • strong medicine for sprains, joints and bones	• grows well in high mountains, colder areas only
Sesbania grandiflora (hummingbird tree)	• all year supply • high in proteins, vitamins and minerals • eat leaves, young pods and flowers • beautiful flowers	• grown from seeds • drought tolerant
Coconut	• regular supply (all year if you have many trees) • source of proteins, carbohydrates and minerals • eat fresh and cooked	• tall tree • grown from seeds • grows very well up to 500 metres above sea level
Banana	• regular supply (all year if you have many plants) • source of carbohydrates, vitamins and minerals • eat fruit fresh and cooked	• grown from propagation • loves wet areas • perennial and very easy to grow
Papaya	• regular supply • high in vitamins • eat fruit green and ripe, leaves and flowers • strong medicine	• grown from seeds • easy to grow • does not like soil too wet
Gotu kola	• source of vitamins and minerals • bitter vegetable providing many health benefits • health tonic and strong preventative medicine	• grown from propagation • grows in sun or part shade • ground cover • dry tolerant
Aloe vera	• great medicine for skin, hair and healing burns and bites • good internal medicine too	• loves dry and very drought tolerant • perennial
Ginger	• spice for cooking • strong medicine for colds, muscles, health tonic	• grown from propagation • best grown in part shade • small plant
Tumeric	• spice for cooking • strong medicine for colds, healing cuts and sores, health tonic, kidneys • beautiful flowers	• grown from propagation • grows in sun or part shade • small plant

IMPORTANT PLANTS FOR AROUND THE HOUSE

Plant	Benefits	Growing habits
Lemon and lime	• important fruit with high vitamin C content • good health tonic • used in cooking and for many different drinks	• grown from seeds or propagation • does not like soil too wet
Chili	• spice for cooking • strong medicine for health	• grown from seeds • grows in sun or part shade • does not like soil too wet
Cassava (leaf and root)	• leaves all year round, providing iron and other nutrients • root crops • living fences	• grown from cuttings • grows on the coast and in mountain areas • does not like soil too wet
Other cooking herbs	• for cooking, grow close to house so they are there when needed • many are medicines too	• grown from seeds or propagation • growing conditions vary from plant to plant • mostly small



SMART IDEA: FOOD RESERVES

Create a community strategic food reserve, storing dried food and growing food plants on community-owned land, using drought-tolerant trees and plants. The changing climate with uncertain rainfall makes it very important for communities to be prepared for difficult times.

Plan an all-year food supply

FOOD CALENDAR

A good technique for planning a continuous food supply is to make a food calendar.

Step 1: Make a list, written or with drawings, of all the vegetables and grains you want to grow. Fruits, such as jackfruit and avocado and the perennial crops in the table above, can be included as well.

Step 2: Write down when you plant each vegetable and grain, and which month(s) you harvest each vegetable and grain.

Step 3: Draw the two calendars and write for each month of the calendars what is planted and what is harvested.

Step 4: Look at the months where there is no harvesting.

A. What else can you grow to be harvested that month?
B. Can planting some vegetables at different times help to add more harvests?
C. Are there other types of vegetables that can be grown at different times of the year?
D. Can different gardening and water-saving techniques make the harvest times for vegetables longer?
E. Are there vegetables that can be harvested for most or all of the year?
F. Can your community bring in irrigation or pumped water to increase growing times?

Step 5: Try to have at least four vegetables or grains harvested during each month of the year.

Step 6: You can also make a food calendar for fruit and nuts.

Remember for planting continuous crops, a sufficient water supply is needed. If you have a water supply or live where there is a second wet season, planting can be extended to most or all of the year. Mulch, compost and good garden designs help hold water in the soil for longer. This reduces water use and helps to maximise rain storage for plants. It also extends the production period for vegetables, which is very important in dry areas.

Creating a strategic food reserve

Every garden, old and new, should have a mix of perennial and annual plants. Every family garden should also be able to provide food all year round. A small variety of tough, drought-tolerant plants, including green and root vegetables, peas, beans and fruit, can provide basic energy and nutritional needs. Make sure enough of the garden is given to those plants. The rest of the garden can be for other vegetables, fruit, herbs and spices for home and for the market, as well as flowers and ornamental plants.

Having a collection of dried food – beans, fruit, vegetables and cassava – and seeds for sprouts builds on your food reserve, and also store some spices and dried herbs so it tastes good too! Replace this food after every harvest so it is always fresh.

This strategic food reserve provides an all-year supply with minimal effort, especially during hungry months, and in emergency and disaster situations.

GREEN VEGETABLES	PEAS AND BEANS	ROOT VEGETABLES	FRUIT
Cassava	Pigeon pea	Cassava	Papaya
Sweet leaf	Sword bean	Sweet potato	Banana
Moringa	Madagascar beans	Yams	Pineapple
Sweet potato leaves	Mung beans	Lotus, bulrushes, water chestnut	Citrus
Brazilian spinach	Yellow and green peas	Edible cannas including arrowroot	Mango
Broad leaf ginseng/ Philippine spinach	Local pea and bean varieties	Jicama	Panama berry
Gotu kola		Yacon	Other drought-tolerant fruit trees
Water spinach, water cress			
Rosella (Hibiscus sabdariffa)			

Storing, drying and preserving vegetables

Good storage means that vegetables last much longer and keep more vitamins. Fewer vegetables rot, and there is more chance of selling them. Most root vegetables are best stored in the ground until they are needed, but for other vegetables a good storage method is essential.

After harvesting, clean and remove any rotten leaves from the vegetables. Store them in a cool place out of the sun and protected from insects and animals.

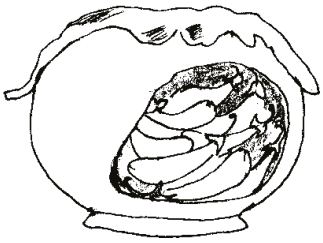
Storing vegetables in clay pots at the markets

Natural cold food storage

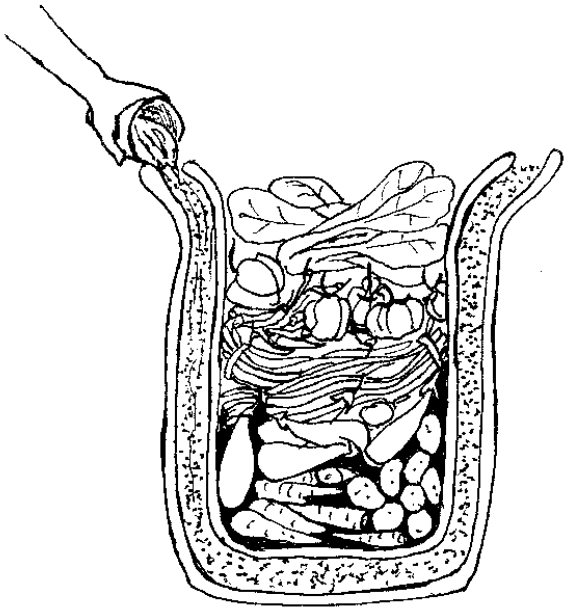
If meat, vegetables and fruit are kept cool, they last much longer. Refrigerators are too expensive for many people and rely on electricity to work.

CLAY POTS

Clay pots are excellent for vegetables. Cover the top of the pot with a damp cloth, and make sure it stays moist: use string or rubber bands to tie it on. Keep it away from the sun. The vegetables stay fresher for many days longer.



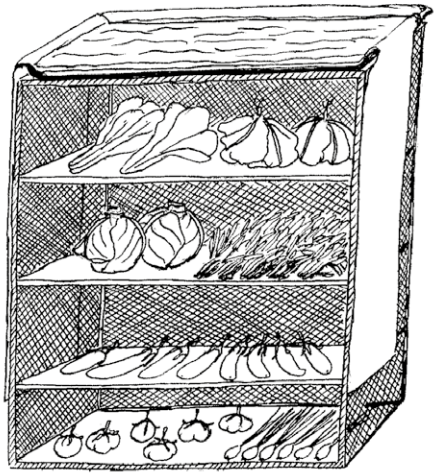
In some Africa countries people use two clay pots; a smaller pot within a larger pot. Wet sand is placed between them. Cover the pots and keep them out of the sun. This technique works even better than one clay pot.



THE COOLGARDIE SAFE

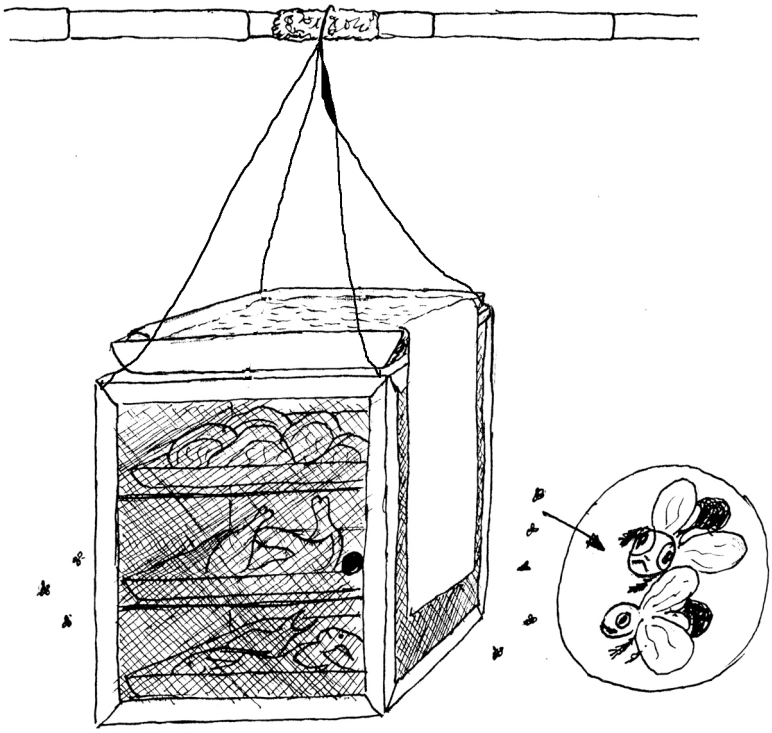
The Coolgardie safe, invented in Coolgardie, a desert town in Western Australia, is a simple way to keep food cool, as well as protecting it from animals and insects.

The safe is a wooden box with shelves inside for the food. The box can be as big or small as you need. One side opens as a door. All four sides have insect screens with wooden edges allowing wind to blow through, but stopping animals and insects. On top of the box is a tray filled with water. A large piece of hessian sits in the tray and hangs down over two sides, drawing the water from the tray and down the sides. This works on the same principle as the wick in a kerosene lamp. Wind blows through the wet hessian, keeping the food inside cool. Add water to the tray whenever necessary.



Cross section of a Coolgardie safe

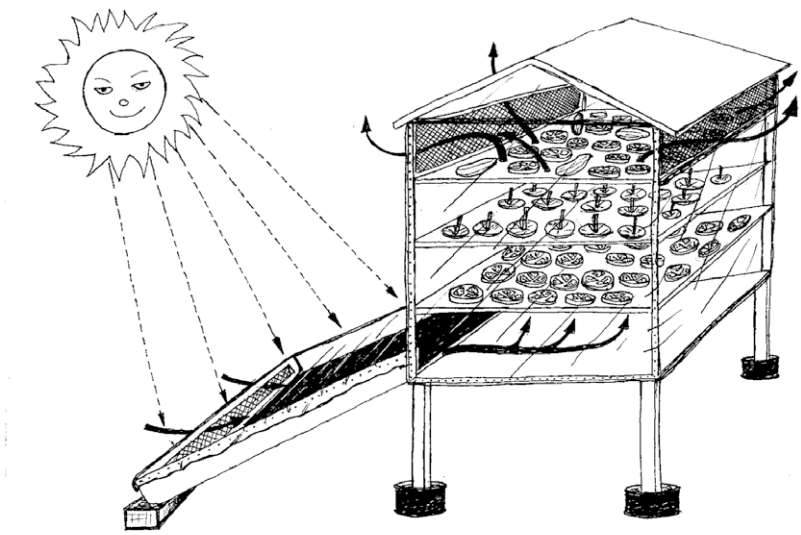
The Coolgardie safe can be hung from a roof or placed on a stand. It is important to put it outside in a place that gets wind. They are cheap and easy to make, helping fruit and vegetables last many days longer. It can also be used for meat but always be VERY careful when storing fresh or cooked meat. Store meat on washable trays at the bottom of the safe, and keep the trays separate from fruit and vegetables.



Natural food drying

During the year there are times when a lot of food is ready to pick or use all at once. Often this food cannot be sold or eaten and is wasted; sometimes it is fed to animals such as chickens or pigs.

Drying the food preserves it with all the nutrients, so it can be stored and used later. This means there is more food for people, especially during "hungry months" at the beginning of the wet season when less fresh food is available. Less food rots or is wasted, and dried food can also be sold at markets or traded.



Solar dryers are great for drying vegetables, fruit, fish and meat. They are much better than drying the food in the open air because:

- They stop insects and animals from eating the food.
- Keeping insects and animals off the food prevents them spreading disease to people.
- The food dries much faster. Fish that normally takes a week to dry, takes two days in a solar dryer. Much more produce can be dried in the same amount of time.

Important: always separate meat and fish dryers from fruit and vegetable dryers to prevent any bacterial contamination, and to stop your fruit and vegetables from smelling like meat or fish!

There are many types of solar dryers, big and small, but here are two basic types made in many countries.

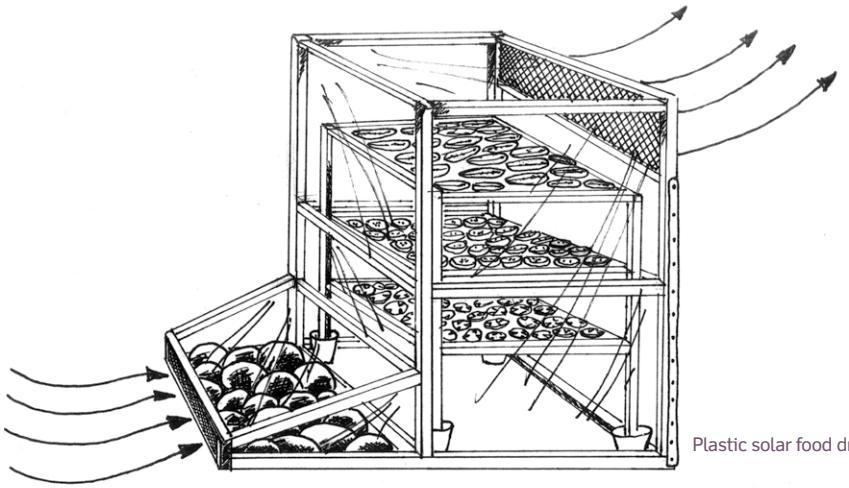
PLASTIC SOLAR DRYER

The plastic solar dryer is a very simple design. It has an outer shell or skin, made of a wooden frame and tightly covered in clear plastic. The side of the dryer can be opened for easy access.

Inside are shelves made with a wooden frame and insect wire as the base. The shelves are separate from the plastic frame so they can easily be inserted and removed. This makes preparation and cleaning easier. In the solar dryer the wooden legs of the shelves are put into tins filled with water to prevent ants from damaging the food.

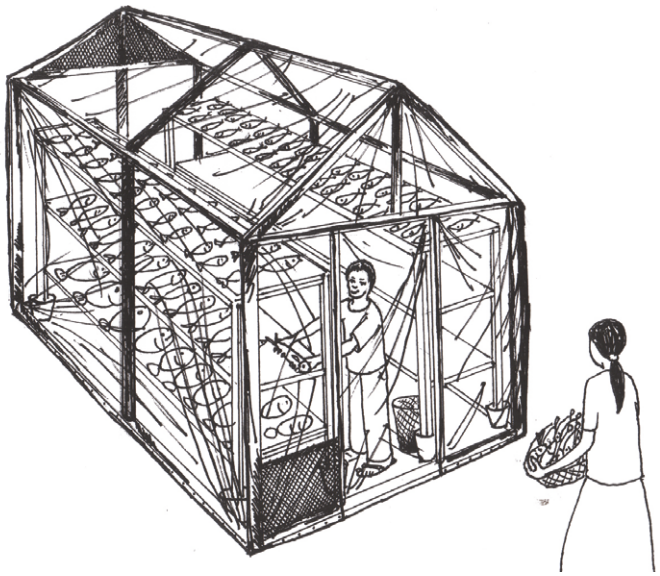
At the bottom in the front an extra section is added to catch hot air. The top is covered with clear plastic, but the bottom front section is covered in insect wire and filled with rocks or old bricks. The top section at the back is also covered with insect wire instead of plastic.

Hot air collects in the bottom section as the rocks/bricks heat up. It then rises to the top of the dryer, and moves out through the insect wire. More air is then pulled in through the bottom, in what is called convection. It creates airflow inside the solar dryer, removing moisture, so the food dries faster and does not rot. At night the air movement continues because the rocks/bricks slowly release the heat they collect during the day, and it still rises and dries the food.



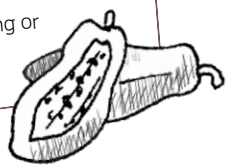
Plastic solar food dryer

Oecussi fish solar dryer



SMART IDEAS: SOLAR DRYERS

- Clean the wire racks regularly with vinegar to prevent bacterial problems, especially if you are drying meat or fish.
- Painting the rocks/old bricks black means they store more heat. Therefore, the dryer works even better.
- Build a fence around the solar dryer to keep dogs and other animals from entering or damaging the dryer.



WOOD AND GLASS SOLAR DRYER

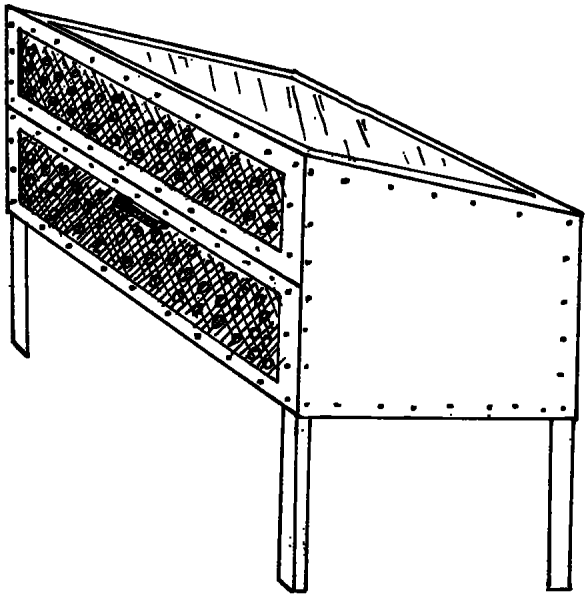
This particular solar dryer is more expensive and more difficult to make, but it dries food faster and lasts many years longer than the plastic solar dryer.

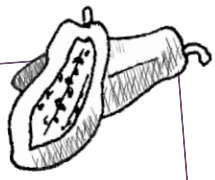
The dryers are easy to clean. If they are well maintained, they can last for five or more years. Keep the dryer away from rain, and lay it flat. **They produce more heat than plastic solar dryers, and are better for stopping bacteria, moisture, insects and animals.** As with plastic solar dryers, ventilation is essential.

Drying times for food:

- Big fish – three days.
- Small fish – one and a half days.
- Vegetables – one day
- Meat – three days for meat cut in slices 3 cm thick.

Look in the reference section for websites with detailed information about these and other types of solar dryers.





COMMUNITY IDEA: SOLAR DRYERS

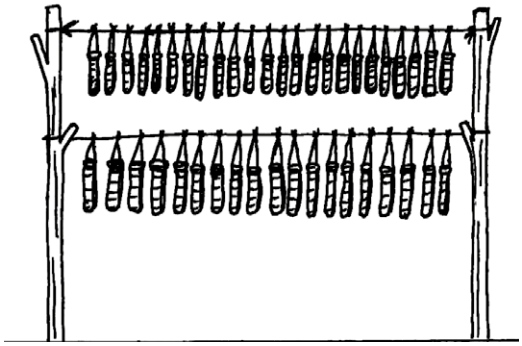
Solar dryers could be made for market places to dry produce that is not sold. Food sellers can join together to make and use a dryer.

Drying and storing meat

Meat goes bad very quickly in a hot and humid climate and is wasted. The wastage impacts on people's incomes and on the environment. Large animals consume a lot of food and water, and if the meat is wasted, the food and water is also wasted. There are some simple methods to make fresh meat last much longer.

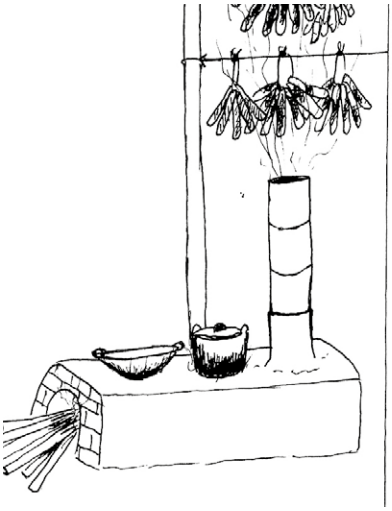
DRYING MEAT

Method 1: Meat is cut into small pieces and dried using a solar dryer. The solar dryer method is best because it protects the meat from insects and animals, and the meat dries much faster. First rub the meat with salt to help preserve the meat for longer.



Method 2: Any type of meat can be dried and salted. Cut the meat with the grain into strips of any length, but make them 3 cm wide and 1 cm thick. Make a solution of 7 litres of water and 1 kg of salt. The solution (brine) must be salty enough to float a raw egg in its shell. Soak the meat strips in the brine solution for two days. Remove them and wipe dry. Then tie the meat to wire or thin rope with dry grass hang in the sun and protect it from flies. When it is dry the meat strips can be smoked or stored in a place with good air flow and free from insects.

Method 3: Smoking meat. It is best to soak the meat in a brine solution (as above) or rub lots of salt on it first, so the meat lasts much longer. The idea is to dry the meat but not to cook it. The smoke adds flavour and preserves the meat. Use a wood which adds a good flavour, such as hardwood from guava, mulberry or citrus. Eucalyptus and pine wood are not good because they are too strong and bitter. A clay stove with a chimney pipe is the best way to direct the smoke onto the meat. Hang the meat strips above the chimney pipe. After smoking, store the meat in a place free from insects with good air flow. A smoke house is another option; they are simple to make and use. Look in the reference chapter for ideas.



STORING MEAT

Always store the meat so it is protected from insects and animals. Good air flow is also important. If you have specific containers in which to store meat, ONLY use them for meat, not for vegetables, bread or other food. The bacteria from the meat make other food go bad much faster. A "Coolgardie Safe" – a wire box that keeps produce cool and protected – can be used to store both fresh and dried meat. Read earlier in this chapter for how to make and use one.

Preserving food

Vegetables and fruit can be preserved as sauces, pastes, pickles and jams. This reduces waste, provides more food during hungry times and can also provide income. Some examples are:

- Sauces: tomato, chili, tamarind
- Pastes: peanut, cashew
- Pickles: cucumber, onion, capsicum, cabbage, mango, lime, bamboo
- Jams: all fruit except watermelon

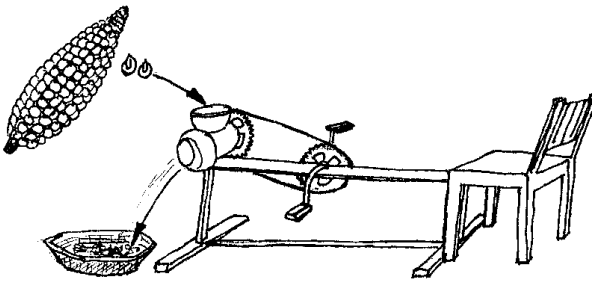
Fermented food includes pickles, pastes, and sauces. Some vegetables can be dried and stored in oil for later use such as eggplant, capsicum, chili, tomato.

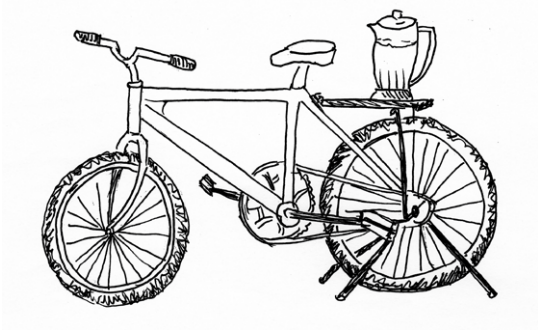
Look in the reference section for where find recipes.

Pedal-powered food processors

This is simple but very effective technology:

- A grinder for corn, rice, nuts and more is connected to a bicycle, or to a separate pedal, cog and chain section. Instead of the chain spinning around and turning a wheel, the chain spins a separate cog, which then spins the grinder. It is much easier than pounding or crushing the corn, and much cheaper than using a petrol grinder.
- Food blenders can also be pedal-powered for electricity-free fruit juices and smoothies.
- New pedal-power technology is developing all the time, with pedal-power electricity generators now available.





Oil extraction

Oil can be extracted from different fruit, nuts and seeds for use in cooking, to add to other food, for making soap, candles, and massage oil, running engines and much more. There are many plants and trees in tropical countries that provide oil, such as coconuts, candlenuts, macadamia nuts and avocados. The oils greatly improve nutrition, especially for children, or can be sold or traded. Good quality organic oils are a possible export product.

A simple method for extracting oil, appropriate for most places, is an oil press. There are many different types and sizes that can be used.

The press simply squeezes and crushes the material until the oil is released. The oil then needs to be cleaned to remove any other substance. Good storage is essential for the oil to last a long time:

- Store the oil in glass bottles or jars if possible, with good lids.
- Fill the bottles to the top or the oxygen in the bottle makes the oil go rancid quickly.
- **Always** keep the bottles away from sunlight.

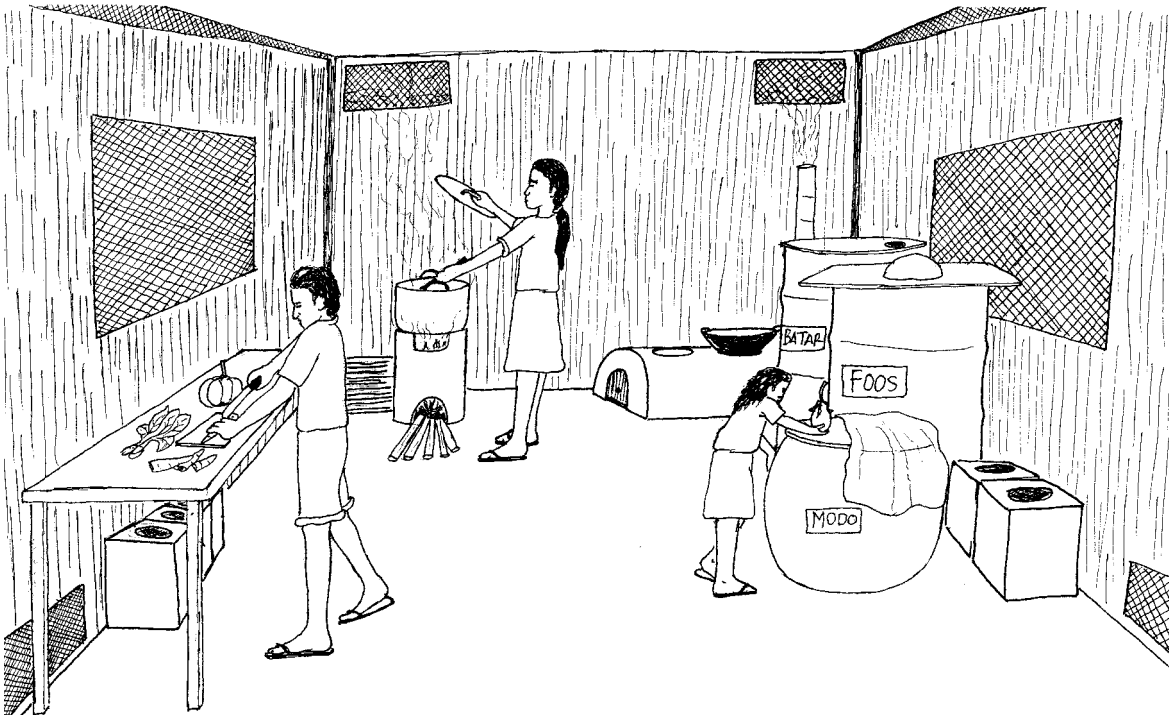
Look in the reference section for more about oil presses and oil production.

Cooking with ovens and stoves

Ovens and stoves are possibly the most important simple technology to make and use in tropical countries.

- They use a lot less firewood, and so save a lot of money AND help protect the environment.
- You save time and energy by not collecting firewood.
- A lot less smoke is produced, which is very important for improving health.
- Some stoves use rice and coffee husks, sawdust, charcoal bricks, bamboo bricks or biogas instead of wood.
- Some stoves cook your food and produce biochar (soil improver – read **Ch 9** Soils) at the same time.

Ovens and stoves are a great business idea for cooperatives and small enterprises. It is important to work with governments to promote, support and educate communities about using stoves and ovens, as they are a vital part of protecting forests and reducing climate change.

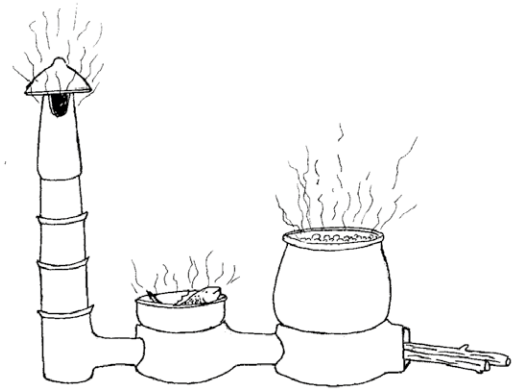


CLAY STOVES

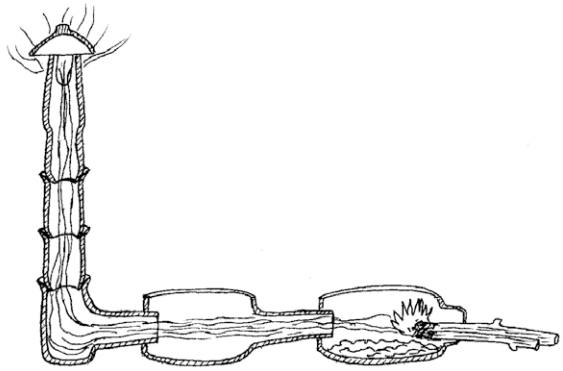
Clay stoves are traditionally used in some regions and are very simple to cook on.

Make the fire at the bottom of the stove and place the pot on top. The clay directs the heat and flames up to the bottom of the pot. The clay also becomes hot providing more heat for cooking. Only a small amount of wood is needed compared to a normal fire.

There are many different types of stove; they vary from region to region.



Clay stove made in separate sections with two burners and a chimney

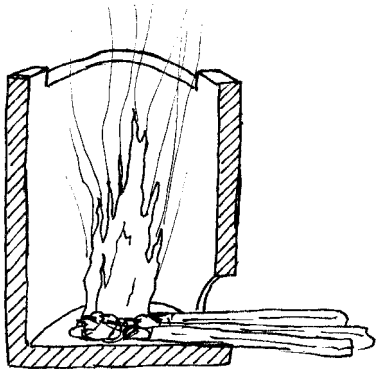


Cross section of two burner stove

Making a simple clay stove

Use the following combination of material: clay (75%), dry cow manure (25%) and a small amount of cement, if available.

- Add some water to make a mix that is moist but not wet.
- The stove base is a circle approximately 30 cm in diameter and 5 cm thick.
- The stove wall, securely connected to the base, should be about 5 cm thick and 40–50 cm high.
- Cut three sections out of the top, 3 cm high and about 10 cm long, so it looks like a castle. This is essential for good air flow.
- A small semi-circle hole at the bottom of the wall, 10 cm in diameter, is for the sticks.
- If possible the stove should be fired (baked) in a kiln. This makes the stove stronger and last A LOT longer.

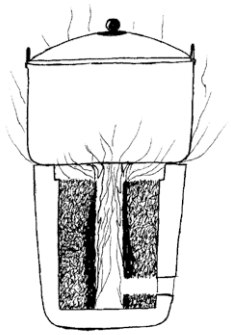


Cross section of simple clay stove

CEMENT AND SAWDUST STOVES

This idea comes from Liklik Buk: *A Sourcebook for Development Workers in Papua New Guinea.*

A cement stove is cheap, long lasting, easy to make and move, and burns with little or no smoke. It uses sawdust from bamboo or wood as cooking fuel. It may also work with rice and coffee husks, but these fuels have not yet been tried. Experiment with fuels to see what works best.

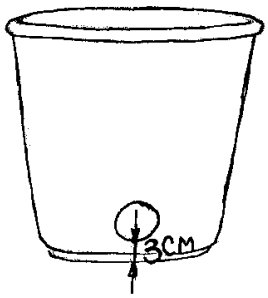


You need:

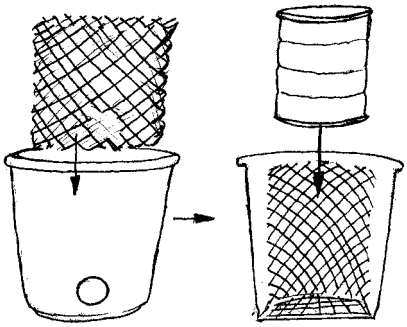
- A 10 litre sized bucket
- Thin wire mesh, about 60 cm x 60 cm
- A sharp knife
- Tin snips if you use tin
- A wire cutter
- Cement (a quarter of a bag for one stove at most)
- A large 2 kg sized tin (milk tin, or some old roof tin moulded to size or even a plastic water/coffee jug)
- Two pieces of bamboo about 4–5 cm wide (finger length) and 50 cm long (make sure it is taller than the bucket)
- Sand

How to make the stove

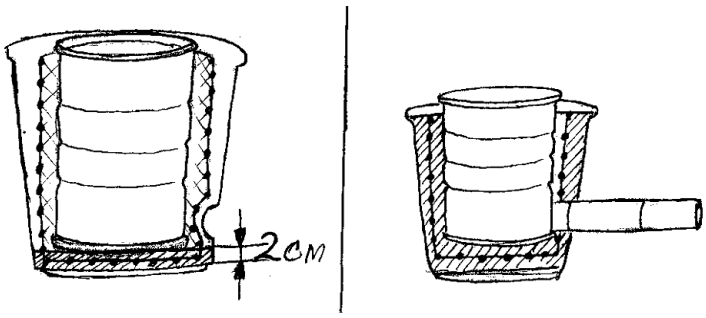
1. Cut a circle in the side of the bucket, 3 cm from the bottom and as wide as the bamboo.



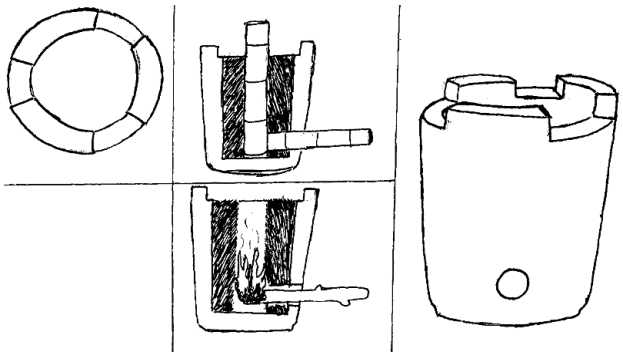
2. Mould the wire so that it fits inside the bucket close to the sides and bottom but without touching it. The wire should also be 2 cm below the top of the bucket.



3. Mix the cement, about one part cement to three parts sand. It should be a fairly dry mix. Put about 2 cm of cement into the bottom of the bucket. Place the wire in the bucket so it sits in the wet cement; make sure the wire is completely covered. Place the tin on the cement, and make sure the wire does not touch the bucket or the tin. Cut a hole in the wire in the same place and same size as the hole in the bucket. Put a bamboo piece through the hole until it touches the tin. Put a stone in the tin to stop it from moving. Carefully fill the space between the bucket and the tin with cement. Poke the cement with a thin piece of wire occasionally to remove any air. Fill the bucket with cement up to the top.



4. When the cement is about an hour old, carefully make three cuts into the top of the cement, spaced evenly, 1 cm deep and 2 cm wide. These cuts provide air flow when cooking and are essential for the stove to work.



5. When the cement is firm, carefully remove the tin by slowly twisting and pulling. Remove the bamboo as well.

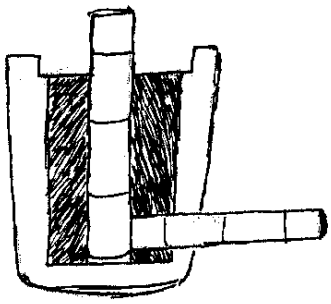
6. Put the bucket in a dry, dark place and leave for two days.

7. To remove the bucket, tap it gently with a stick then turn over and shake until the cement stove slides out. Do not let it fall! Cover it with a damp cloth and keep it moist for a week so the cement sets properly.

Using cement stoves

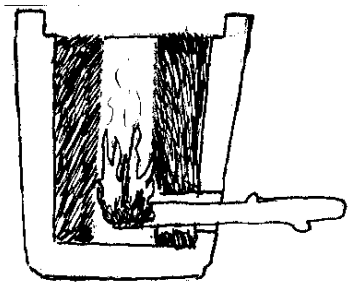
1. Take the pieces of bamboo and place one piece in the centre of the stove pointing straight up. Place the other piece through the hole so it touches the first bamboo piece.

2. Begin pouring sawdust into the stove from the top. Tap it down continuously so it is very firm. Keep filling the stove until the sawdust reaches the top and again make sure it is very firm.



3. Carefully twist and remove the central piece of bamboo. Push the bottom piece of bamboo until you can see it through the top hole, then carefully twist and remove it. The sawdust must not move at all. You should then have an "L" shaped tunnel that the fire and air go through.

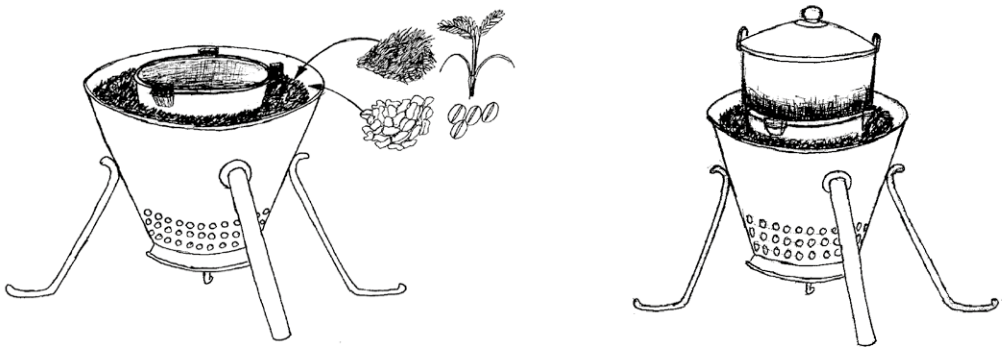
4. To light the stove, take a finger-thick piece of dry wood and dip it in kerosene. Put it in the bottom hole so you can see it from the top. Then light a match and drop it down.



5. The sawdust slowly burns, and a good flame should continue as long as the stick is fed into the stove. Once the sawdust in the middle is bright red, the stick can be removed. The stove then provides constant heat for two hours. If more heat is required, feed in another stick

TIN METAL STOVES

Tin metal stoves use rice or coffee husks to burn instead of wood. They have been built and tested in many countries with good results. They are designed so air enters through the bottom and keeps the rice or coffee husks burning continuously. Less smoke is produced than a wood fire. Look in the reference chapter for where to find plans for making and using tin metal stoves: they are quite cheap and local blacksmiths could make them.



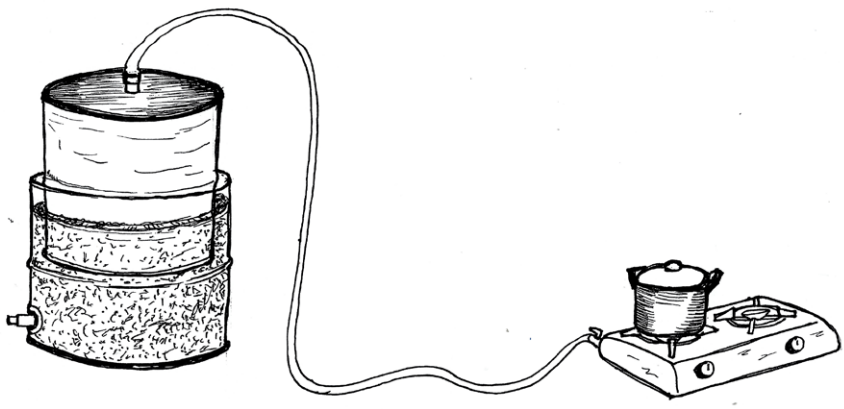
GAS STOVES USING BIOGAS

Biogas systems collect methane gas from rotting manure and leaves, which is used for cooking and generating electricity. Read Houses, Water and Energy (**Ch 7**) for more information. Biogas systems can produce constant supplies of free cooking gas for the house, and the manure and leaves become great fertiliser afterwards!

The biogas system is connected via pipes, with a regulator, to gas burners in the kitchen.
(The gas does not smell either.)

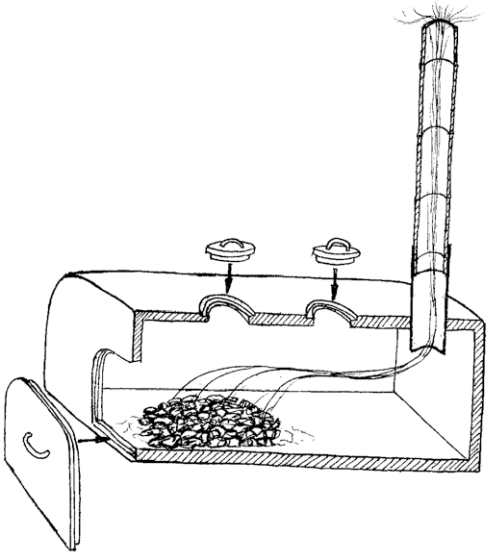
Benefits:

- They are much easier and cleaner to use than wood fires.
- They do not produce smoke.
- They reduce the very serious problem of deforestation.
- They turn waste into many resources.
- Methane gas from manures and rotting leaves contributes to climate change, but if it is collected and burnt it does not.



CLAY OVENS

Clay ovens are made in many different ways. Small simple ovens can be used just for baking inside the oven (bread, cakes, etc.) Larger ovens can be used for baking and also as stoves to cook food on top. These ovens have a chimney to draw smoke away from people and possibly out of the kitchen. Clay ovens are usually made from clay, dry cow manure and a small amount of cement.



Cross section of two burner clay oven

Two different types of clay ovens are described here, but there are many other excellent designs to use.

Design 1

Use clay bricks for the bottom and sides. Cover them with a thick render made from clay (75%), cow manure (20%) and cement (5%, if available).

Use wire to shape a frame for the top. Make two or three holes in the wire, about 10 cm wide for cooking pots. The top should be flat so the cooking pots can sit on it. Make one more hole at the back of the oven for a bamboo chimney to let the smoke out. Cover the wire with the clay mix, 10 cm thick so the wire is in the middle.

Door. The door at the front has to be large enough to allow you to put in your largest cooking trays. It must be 10 cm thick, the same as the oven, and fit very well to stop smoke and heat from escaping.

Chimney. Make a round tin metal sleeve for the bottom of the chimney, about 20 cm long and wide enough for a dried bamboo pole to fit into the top.

Place the chimney into the prepared hole and use the clay mix to seal the gap and hold the chimney in place. Also use the clay mix to seal any gaps between the metal sleeve and the bamboo.

Lids. Make lids for the cooking pot holes to cover the holes when you are not using the cooking pots. Make a wire frame base for the lids, and cover with clay until it is 10 cm thick. Add a wooden or metal handle on top of the lids. They MUST fit very well into the holes to stop smoke and heat from escaping.

Design 2

Follow the same steps as Design 1 but make a wire frame mould to shape the whole oven.

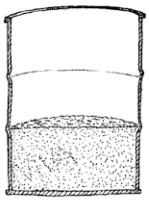
Make sure that the whole oven is at least 10 cm thick.

DRUM OVEN

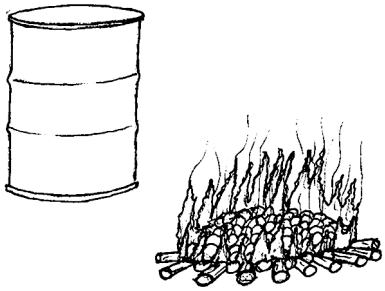
A drum oven is a simple way to cook a lot of food using a drum, sand, rocks and banana leaves. It uses a lot less wood to cook the same amount of food as a cooking fire. It also keeps many more nutrients in the food than boiling or frying does.

Step 1: Cut the drum in half. Clean the inside well with detergent and water. Rinse it very well with water and leave it in the sun for a few days. Beat the sharp edges down.

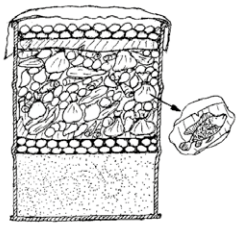
Step 2: Fill the drums a third full of sand.



Step 3: Collect a small pile of hand-sized rocks. Make a fast fire from palm leaves, bamboo leaves, small sticks, etc. to heat the rocks. (Do not use rocks from the river as they may explode!)

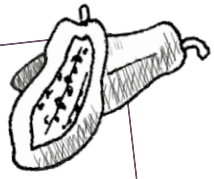


Step 4: When the rocks are very hot, use a shovel to put two layers of rocks on the sand. Then put two layers of fresh banana leaves on the rocks. Place the food on the banana leaves. You can cook meat, fish, cassava, sweet potatoes, potatoes, corn, bananas, pumpkins, yams, carrots and more. Then place two more layers of banana leaves and two more layers of hot rocks. Cover the top with an old cloth and tie it on tightly with twine. Leave it to cook for two hours.



Step 5: Remove the cover, rocks and banana leaves, and eat the delicious food!

SMART IDEAS: COOKING IN THE GROUND



The same cooking method can be used for a hole in the ground. In areas with sandy soil this is a much simpler method and is common for ceremonial feasts in Melanesian and Polynesian countries.

Cooking bricks

Firewood is expensive, collecting it is hard work, it creates a lot of smoke and using it is destructive to the environment. Cooking bricks are a fuel that last a long time and produce very little smoke.

COMPRESSED BRICKS

Compressed bricks made from bamboo sawdust can be produced using a small specialised machine. While not cheap, this process uses a waste product to create long-lasting cooking bricks and also generates income. The machine can also use wood sawdust and potentially coffee and rice husks as well. It can be purchased by a cooperative and should be part of any bamboo or wood processing business.

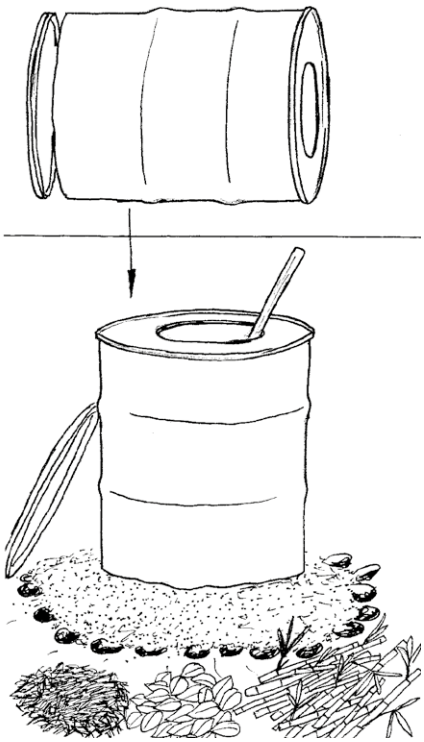
CHARCOAL BRICKS

Charcoal bricks are easily made using a drum and local materials.

Making charcoal bricks

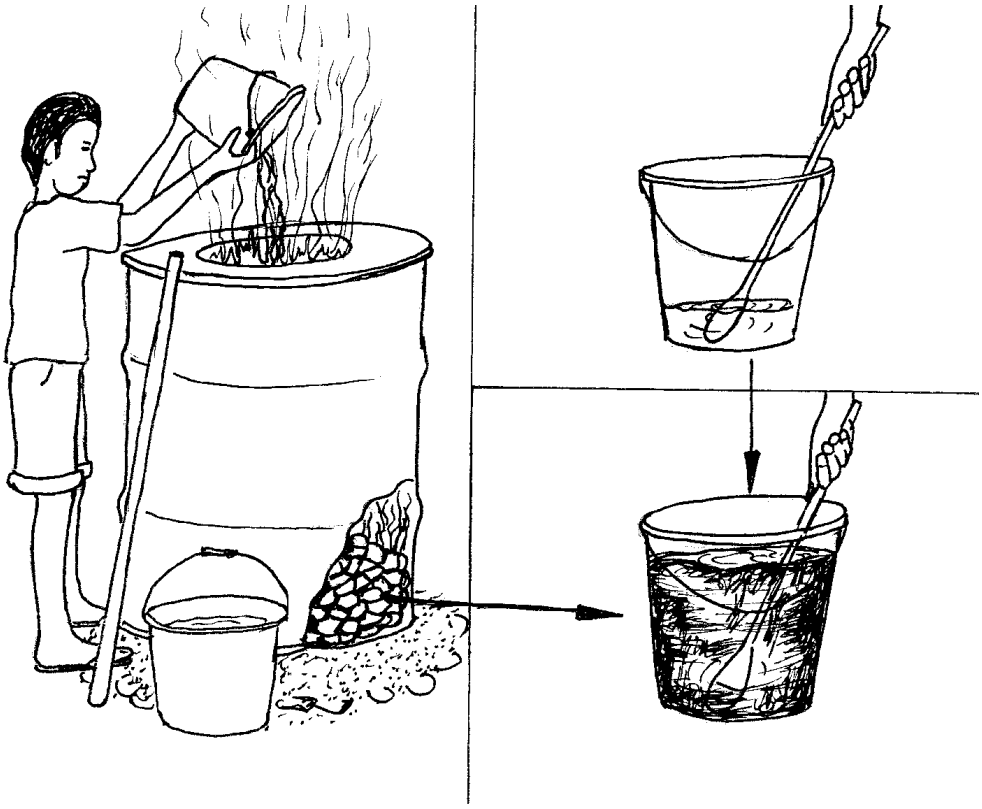
Step 1: Cut the bottom off a drum. Turn it over and cut a small circle, 20 cm wide, in the middle of the other end. Make sure any sharp edges are beaten down. This end is the top.

Step 2: Fill the drum with fresh bamboo leaves, thin split bamboo (not dry), coconut shells and husks, coffee and rice husks, and palm and other leaves. Bamboo is best and much better for the environment too. Burn the leaves slowly and stir the fire occasionally with a wood pole through the hole in the top. Add splashes of water occasionally to slow the burning process, and add more material. When the material has all burnt into black pieces of charcoal, put the fire out with water. The black charcoal is left at the bottom.

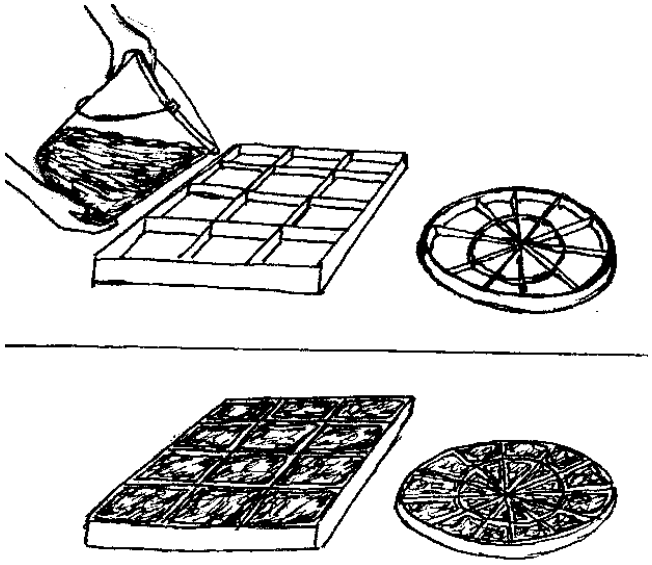


Step 3: Crush some dried cassava root into a powder. Add water to make a thick paste. Or, crush the stems of cassava bushes, put them in a bucket (but not the skin) and mix in water. Leave the mixture to settle. It will separate into liquid at the top and a thick paste at the bottom. Pour off the liquid so only the paste is left. Dried and crushed arrowroot root can be used as well.

Step 4: Mix the black charcoal left in the bottom of the drum with the cassava paste: 90 to 95% charcoal and 5 to 10% cassava paste.



Step 5: Put the charcoal brick mixture into a brick "mould" (see the pictures), and put it in the sun to dry.

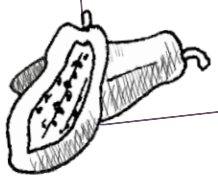


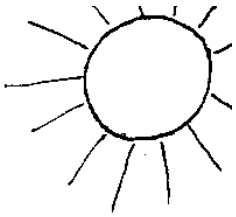
USING CHARCOAL BRICKS

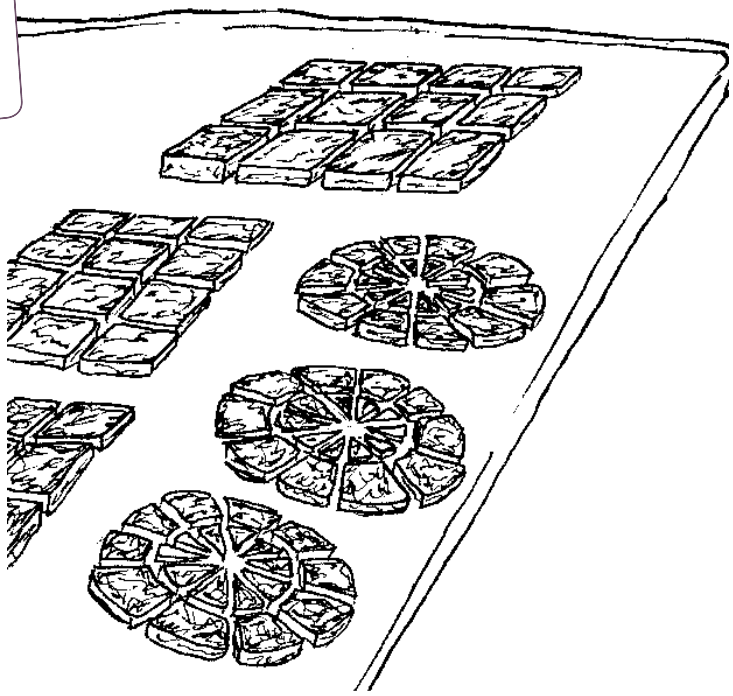
The bricks are great for open fires, in cooking stoves and clay ovens. A brick burns very slowly and produces a constant heat. Start a small fire with sticks then add the bricks when the fire is alight. Add more small sticks if you need to increase the heat, and add more bricks as necessary.

SMART IDEA: COFFEE SYRUP

The thick syrup from processing coffee could also be a potential material, but has not yet been tried. This would turn a waste product into valuable cooking fuel.







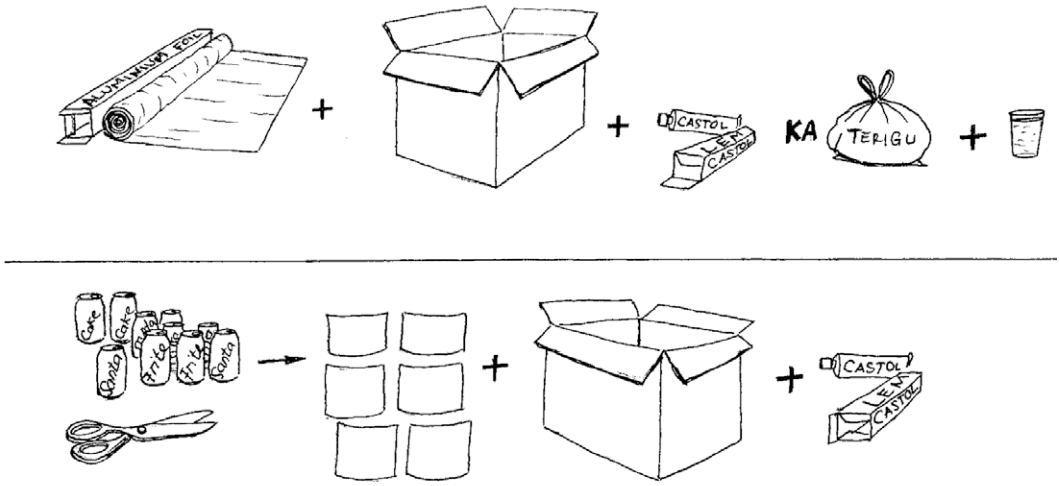
Solar cookers and solar ovens

Solar cookers and ovens use the heat from the sun to cook food. They do NOT use wood or any other fuel! They cannot be used as much in the wet season, but are great for cheap, healthy and environmentally sustainable cooking. Food that can be made in solar cookers and ovens includes bread, soups, meat, fish, curries, corn, rice, and much more.

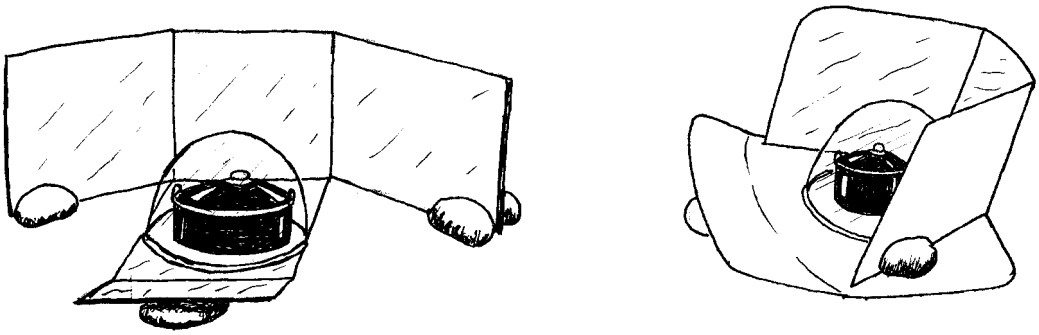
SOLAR COOKERS

Simple solar cookers can heat and cook food. To reduce cooking time you can use a stove or fire until the food is boiling, then put it in the solar cooker. The cooker concentrates heat from the sun and slowly cooks the food.

Parabolic cookers use a dish similar to a satellite dish to catch and direct the sun's heat to the saucepan placed in the middle. They are more expensive to buy or make but they last a long time and reach much higher temperatures. This means the food cooks faster and they can be used for a large variety of cooking and baking.



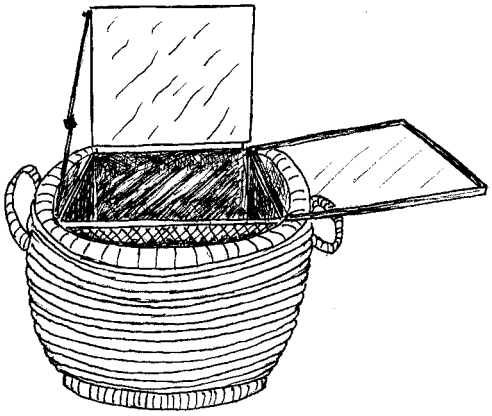
How to make a simple solar cooker



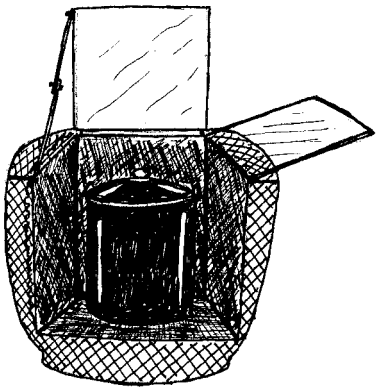
Examples of completed solar cookers

SOLAR OVENS

Solar ovens work very well without needing to heat the food first and can create enough heat to cook any food. They are an insulated, closed box with a glass lid.



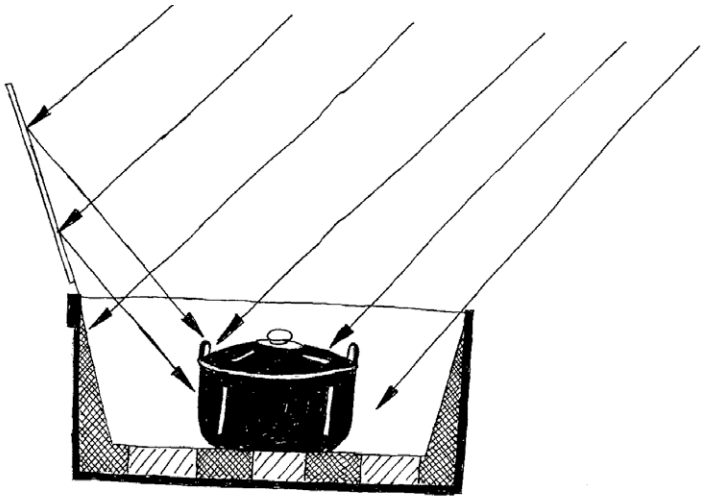
Solar oven made from fibre basket



Cross section

There are many different designs for making solar cookers and ovens that use cheap and easy-to-find materials. Tin foil, tin sheets and glass catch the sun's heat; insulating material (coconut fibre, kapok, etc.) holds the heat; and tin sheets or wood painted black store the heat. Some designs require air holes because they get very hot, and a thermometer to measure the temperature.

See the illustrations for different designs and read the reference chapter for where to find more information.



Cross section of wood frame solar oven

FOOD, HEALTH AND NUTRITION
CHAPTER NOTES

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9. SOILS

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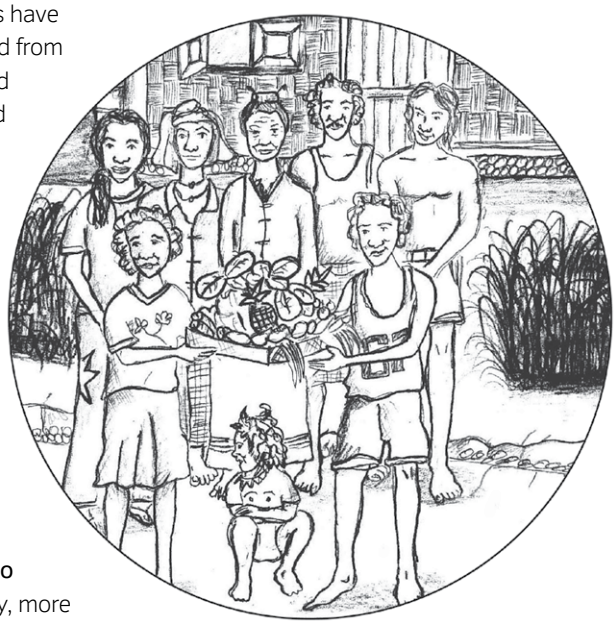
LIVING SOILS 59

The soil beneath our feet provides our food as well as livelihoods for billions of people. It is also essential for the earth's ecosystems and reducing climate change. Soil is beyond value and yet through bad practice it is quickly diminishing worldwide. This chapter explains how to protect, increase and improve your soil, for food and livelihood security and for the protection and regeneration of our earth.

About healthy soil

Healthy living soil is the basis for all agriculture and, as a result, our nutrition. When growing healthy fruit, grains and vegetables, soil is the MOST important factor.

The soil must be replenished each season so the plants have all the nutrients necessary to grow. It must be protected from erosion, to keep the fertile topsoil, and from the sun and wind to save moisture. Very, very small soil animals and plants are called biota (which includes five types of micro-organisms: bacteria, fungi, viruses, amoeba and algae, as well as insects and worms), which are all essential in healthy, living soil, and must be encouraged and protected.



Good soil quality is very important for all gardens and agriculture, on either a big or small scale. Women, who do most of the cooking, home gardening and educating about nutrition, also need to learn more about soil quality, soil science and techniques to improve the soil. The techniques are simple, do not require heavy work and use local materials. **This is because soil quality relates directly to good nutrition** – better quality soil means better quality, more nutritious produce, which tastes better too! This is the best and most direct way of improving health.

Good soil also ensures animals are healthy: when they eat nutritious food they grow better and are healthier. Good soil in fish ponds prevents problems from toxins, chemicals or acidic soil. Pond plants grow better producing more fish food and bigger, healthier fish.

Across all the tropical regions soil is slowly disappearing and losing nutrients, mainly because of burning, erosion and the use of chemical fertilisers, herbicides and pesticides. **This must stop!!** Farmers need to protect their soil as it is the most valuable asset in the garden and on the farm! When you use good soil building and retention techniques, the soil improves and increases each year.

Improving and increasing the soil does not take a lot of extra work in small gardens. More work is needed for larger areas, but the benefits are many and more than repay the work. The rewards multiply over time as the soil quality continues to improve.

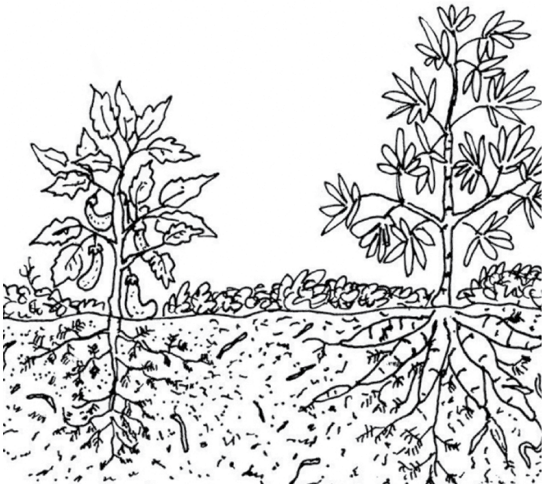
Compost circle turning waste products into organic fertiliser and soil improver

Knowledge about the value of healthy soil is changing, and most scientists now recognise the importance of biota (soil builders) in soil and for food production. This change shows that good soil is the base for sustainable food production. This is even more important because of the negative impacts of climate change and soil depletion worldwide. Healthy soil techniques, which encourage people to stop burning land and vegetation, actually reduce agriculture's contribution to carbon dioxide (CO_2) production and global warming, as well as helping farmers and communities to be more resilient to climate change.

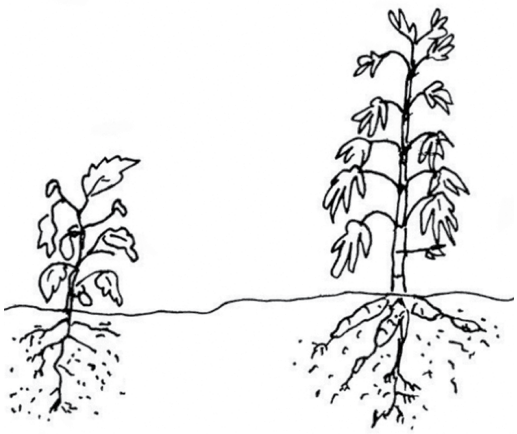
What is healthy living soil?

Healthy living soil contains everything a plant needs for it to grow to its maximum potential.

1. It contains humus. This is made from partly broken down organic matter (OM) compost and mulch, manure, plant roots and plant material. Humus provides food for the soil biota, which then becomes food for plants. Humus also stores other plant nutrients, helps to bind the soil particles together (improving the soil structure) and soaks up water like a sponge.
2. Healthy soil is alive! It contains trillions of soil biota that turn OM and nutrients into plant food. Soil scientists have counted more organisms in a teaspoon of soil than there are human beings on the planet!! Soil biota includes bacteria, microorganisms, ants, earthworms and many, many, many more very small organisms, insects and small animals.
3. It contains a good mix of clay and sand particles, with not too much of either. The clay holds nutrients and minerals, and the sand allows water drainage.
4. Healthy soil should hold together loosely when it is pressed and not be crumbly like sand or sticky like clay.
5. Healthy soil is composed of about 50% clay, sand, humus and OM and 50% air pockets!
   The air pockets are very important because:
   - They provide space for the soil to hold a lot of water.
   - The air provides oxygen that the plant roots need to use the nutrients.
   - They allow easy, fast and deep root growth. Therefore, the plant roots can gather more water and nutrients, so the plant is bigger and healthier.
6. Healthy soil acts as a nutrient bank by storing nutrients ready for plant use. The nutrients are not leached (drained) out of the soil.
7. Healthy soil has a balanced pH level. This means that it is not too acidic (like vinegar) and not too alkaline (like salt). It also has balanced nutrient levels especially minerals, such as calcium and magnesium.



Plants growing in healthy living soil

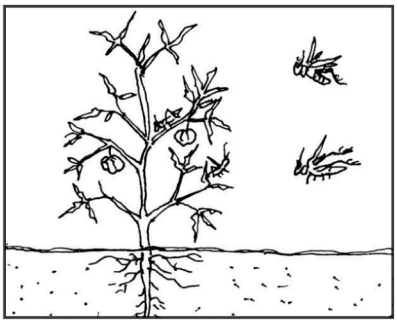


Plants growing in unhealthy soil

Benefits of healthy living soil

With healthy living soil:

- Plants are more drought resistant. The soil can store much more water, and the plants can send roots much deeper into the ground to find water and nutrients.
- Plants are more disease and pest resistant because they have more water and all the nutrients they need for strong and healthy growth. An unhealthy person becomes sick more often, and it is the same for plants.



Low resistance

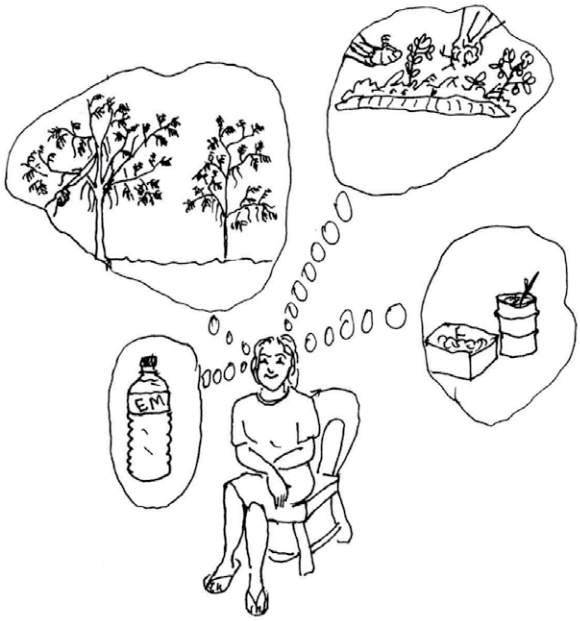
High resistance

- The food plants produce has more vitamins and minerals. This improves people's health, especially for children.
- Less watering is needed because the soil can store more water, and less evaporation occurs. Good soil requires half the water that poor soil needs.
- There are trillions of soil workers that manage nutrient availability and storage. They also help to increase the amount of air in the soil. Worms are particularly hard workers.
- The soil is easier to dig and work with! This is because it has more air and a better structure, and it does not become dry and hard like cement in the dry season. This is very important and saves a lot of time and energy.
- You can save a lot of money if most or all the inputs you use to improve the soil are organic and locally gathered. For example, collecting and reusing all manures and plant waste. Healthy soil needs very few external inputs if you use good techniques.
- The soil does not become water logged in the wet season. Even though the soil can store more water, the good soil structure allows for drainage if there is a lot of rain. Too much water can slow plant growth or kill plants by drowning the roots. The roots need air too! In areas where there is a lot of clay, water logging can be a big problem. Making raised garden plots greatly reduces problems from excess water. This means you can grow more types of vegetables in the wet season, which is very important for reducing hunger periods!
- Food for animals and fish is more nutritious and healthier, and there are more soil animals for chickens, ducks and fish to eat.

Soil workers and garden helpers

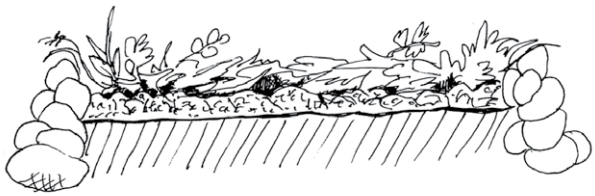
Do

- **Use organic compost and liquid compost regularly.** These provide a range of nutrients, are cheap to make, increase the number of soil biota and continually improve the soil structure and quality.
- **Increase the number of soil biota** – the micro-organisms, bacteria and fungi in the soil. This can be done by using natural fertilisers, mulch, micro-organism activators and biochar (activated charcoal). This improves the soil quality, and all forms of agriculture and animal production.
- **Use mulch to protect the soil from direct sun**, which saves water and increases the humus content.
- **Recycle nutrients** by putting plant materials and animal manures back into the system.
- **Use legumes.** There are many different legumes to plant, and they provide nitrogen for the soil, mulch and organic matter (OM), food for humans and animals, windbreaks and soil retention, animal habitats, diversity and more.
- **Rotate the crop production.** Different plants need different nutrients to grow. Rotating crops makes the nutrient use more balanced and easier to replace. Crop integration also helps.
- **Grow green manure crops** and turn crop waste back into the soil. In the tropics a lot of nutrients are held in plant matter and when it is burnt the nutrients are lost.
- **Use slow release, nutrient-rich, organic materials** to add to your soil, such as biochar and rock dust (waste product from making gravel). Apply once and gain years of benefit.
- **Protect your soil and prevent erosion** with terraces, swales, tree terraces, raised garden beds, garden borders and good water management, so the soil can build up year after year.



Thinking of good techniques

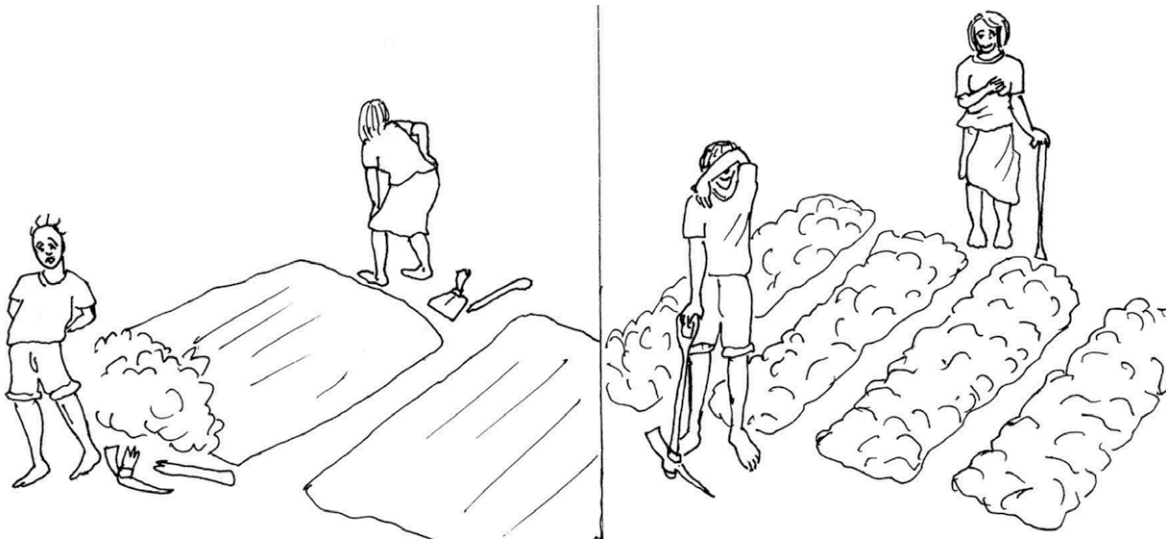
Recycle nutrients



Protect your soil and prevent erosion with raised garden beds

Do not

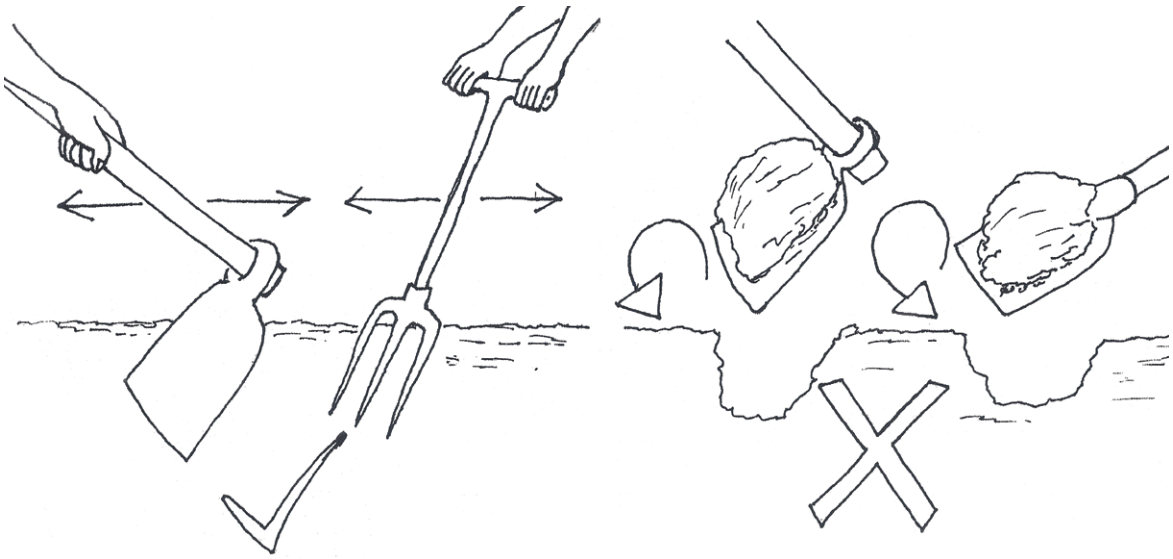
- **Do not use chemical pesticides**, chemical herbicides and many chemical fertilisers, as they kill biota and create imbalance in the soil. Soil biota is your friend and helper for building healthy and balanced soil, and is an important part of organic farming. Scientific research increasingly shows that, over time, chemical farming depletes the soil, becomes more expensive, reduces yields, and it damages people's health and the environment. As chemicals are produced by factories, chemical farming also contributes to climate change.
- **Do not compact the soil**. Soil compaction reduces root growth, water storage capacity and drainage, and damages the soil structure. You also need a lot of energy to dig in the hard soil.



Compacted soil

Non-compacted soil

- **Do not expose the soil to the sun**. This makes the soil dry and hard, and harder to dig. Therefore, the plant roots suffers.
- **Do not waste water**. Water is precious and should be stored in the ground. Water run-off creates erosion, and reduces the number of soil biota if the soil is very dry. They need water too!
- **Do not dig or plough the soil too much**. This creates imbalance for soil bacteria, reduces organic matter and water storage capacity, increases soil fungus diseases, and damages soil structure.
- **Do not leave rubbish around or burn it randomly**. This damages the soil and adds chemicals and toxins to it.



Loosening the soil

Turning the soil

This chapter explains in detail how to apply these "Do's" and provides solutions and better alternatives for the "Do nots"

DANGER!!!
Bad land management causes huge problems!

LAND CLEARING AND BURNING:

- Destroys valuable materials that make compost and provide mulch;
- Destroys valuable plant materials that provide nutrients for the soil;
- Reduces the number of soil biota in the soil;
- Exposes the soil to the sun;
- Dries the soil and increases water loss;
- Creates pollution;
- Creates flooding during the wet season;
- Burning creates CO_2 (carbon dioxide) which contributes to climate change.

LAND CLEARING AND BURNING REMOVES THE SOIL PROTECTION, CAUSING EROSION.

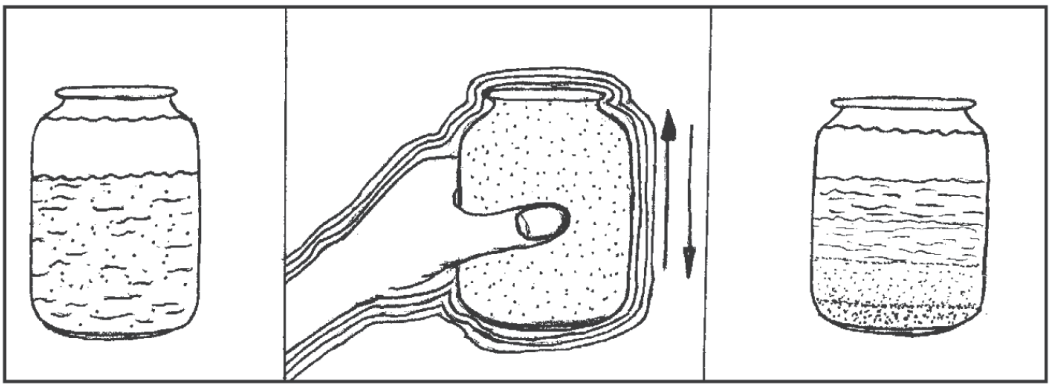
- The first soil that is eroded is the topsoil, and this is the most valuable soil.
- The topsoil contains a lot of nutrients, and takes many years to replace.
- The soil cannot hold water where there is erosion.
- Mulch and fertiliser are also lost to erosion.
- Erosion can also occur on flat land, so protect your soil by using garden bed borders and mulch.
- Tree and plant roots become exposed by erosion, killing the plants or slowing their growth.
- Erosion can lead to landslides and flooding which destroys crops, animals, infrastructure and houses.

Different types of soil - clay and sandy

Soil is mostly made up of clay and sand particles, with a smaller amount of humus and organic matter. Soil varies in the amounts of sand and clay, and the size of the sand and clay particles. A balanced mix of sand and clay is ideal, but good soil can be made almost anywhere using the right techniques.

By using a simple experiment you can identify the type(s) of soil. This knowledge helps you to use the best method for improving your soil. A simple test:

1. Take three or more different soil samples and putting them in separate clear jars or bottles.
2. Fill the bottles to two-thirds full and add water to the top.
3. Cover the top and shake the bottle thoroughly.
4. Now let the soil settle and you can see what type of soil you have. Clay always settles on top, with silt and OM underneath, then fine sand. Coarse sand always settles on the bottom.



Soil identification

This is a great experiment for children to do. Clay soil holds nutrients well, but does not have many air pockets and can become waterlogged in heavy rains. Sandy soil drains well and has a lot of air. However, nutrients easily leach out and it quickly becomes dry.

Improving soil structure

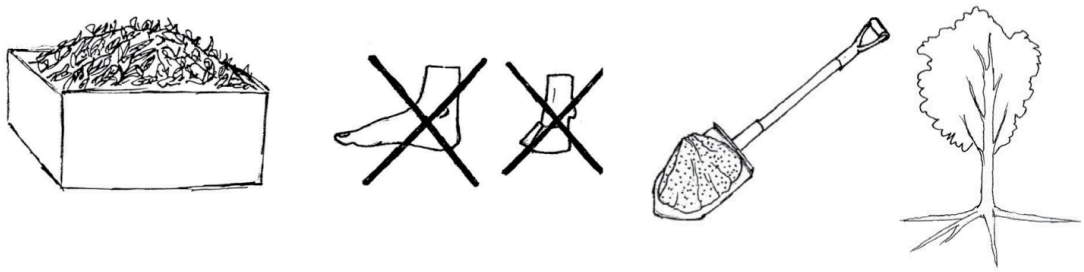
If you have sandy or clay soil, the best solution is the same: use mulch, compost, liquid compost, green manure crops and biochar.

They produce humus and OM and will:

- Improve the structure of and amount of air in the soil
- Increase the number of soil biota
- Increase the nutrient content and availability
- Increase the water storage capacity

IDEAS FOR IMPROVING CLAY SOIL

- Reducing compaction is very important because once the soil is compacted, it sticks together. This makes root growth very difficult for plants and digging very hard for people.
- Adding sand improves the soil structure.
- Green manure crops and crop rotation improve the soil structure over time. Read the 'Legumes' section later in this chapter for techniques.
- Trees and deep-rooted plants improve clay soil. The tree roots break up clay soil and provide mulch too. Trees can be combined with annual crops or even grown instead of annual crops.
- Gypsum sprinkled over the soil at 1 kg per square metre and dug in improves drainage and soil structure. Gypsum also adds calcium and sulphur to the soil. This technique improves the clay soil structure quickly but can be expensive. It does not work well if the soil is too alkaline. (See 'Soil pH' next page.)



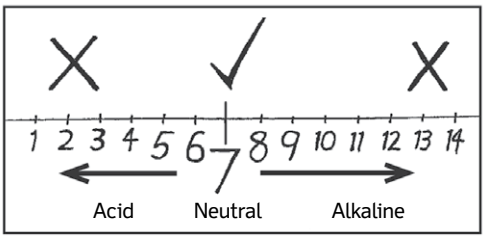
IDEAS FOR IMPROVING SANDY SOIL

- Use three shovels of clay in liquid compost. The nutrients from the liquid compost bind to the clay, and the clay stays in the sandy soil holding the nutrients.
- Mix half a shovel of clay in a large bucket of water and spread it over the soil. Liquid compost is much better, but this technique still adds valuable clay particles.
- Green manure crops add humus to the soil that improves the structure.
- Trees and tree crops help. In dry sandy areas it is better to grow tree crops than annual vegetable crops.
- Biochar (activated charcoal)–explained later in this chapter–is especially good for sandy soil.

Adding clay to liquid compost

Soil pH - acid and alkaline

The pH level is a measure of the acidity or alkalinity of the soil.



It is helpful to compare soil pH with a person's stomach. If your stomach is not in balance (for example, if it is too acidic), it does not work well. It causes problems for the stomach and the rest of your body. Similarly, the soil needs to be in balance to work properly and for plants to grow well.

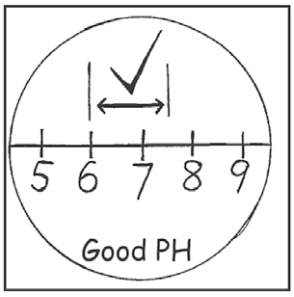
pH chart

If the soil is acidic, nutrients are easily leached out of the soil and productivity is reduced. If the soil is very acidic, only a few plants can grow.

If the soil is alkaline, many nutrients in the soil are "lockup" and not easily available for the plants to use. It greatly reduces productivity and the amount of different plants that can be grown. If you add a lot of mulch and compost, you create more humus that balances the pH, as well as adding a wide range of nutrients.

If you add chemical fertiliser when the soil is acidic or alkaline, a lot is wasted either because of nutrient leaching or "locking up".

Often large areas of land are influenced by certain rock and soil factors to make generally acidic or alkaline soil. An example: Timor-Leste has a lot of alkaline soil because there is a lot of coral and limestone present. A large amount of coastline also increases the percentage of alkaline areas. Also, high calcium content in ground water indicates a higher percentage of alkaline soil.



Identifying soil pH

ACIDIC SOIL:

- More common around wetlands, higher rainfall areas, mountains
- Tastes "sour" like vinegar

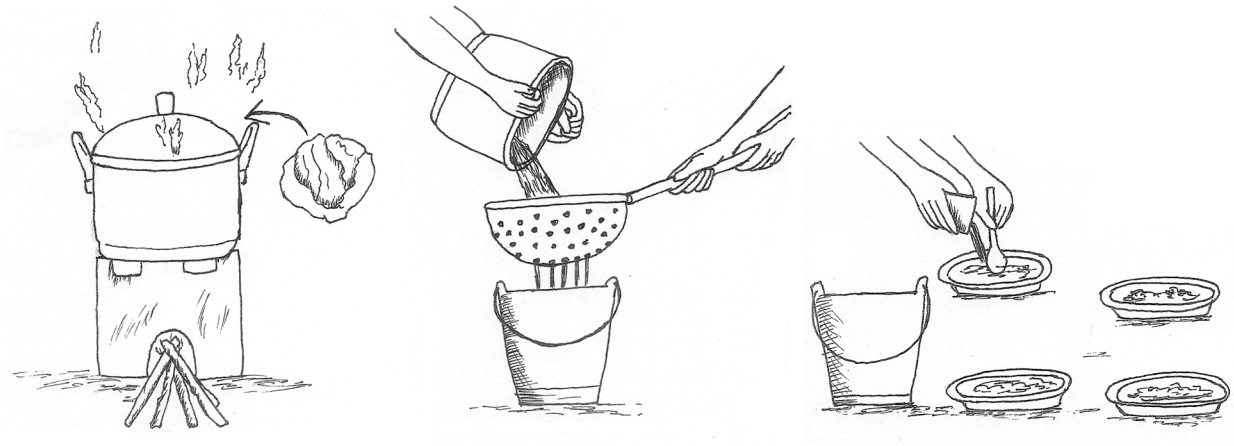
ALKALINE SOIL:

- More common in dry lands, coastal regions and areas of alkaline rock, e.g. limestone, coral
- Tastes "sweet"

Soil pH can be accurately identified using a pH tester. A pH tester gives a number reading from 1 to 14; 1 being the most acidic and 14 being the most alkaline. An "ideal" soil is generally considered to be about 7 or "neutral" because it is neither acidic nor alkaline. Between 6 and 7.5 is still good. Some government agricultural workers, NGOs and agriculture shops have pH testers. However, by identifying the surrounding landforms (e.g. swamps), rocks and common trees you can identify the general pH without needing the equipment.

Another method for finding general pH levels is with a red cabbage!

1. Boil a red cabbage in water.
2. Strain off the liquid into a separate container.
3. Collect soil samples from various parts of your garden or farm, and place them in separate containers.
4. Pour some red cabbage juice into each soil sample until you have a thick mixture.



Wait for a minute and look at the colour of the soil:

Red = highly acidic **Yellow/orange** = acidic **Green** = neutral **Blue/purple** = alkaline

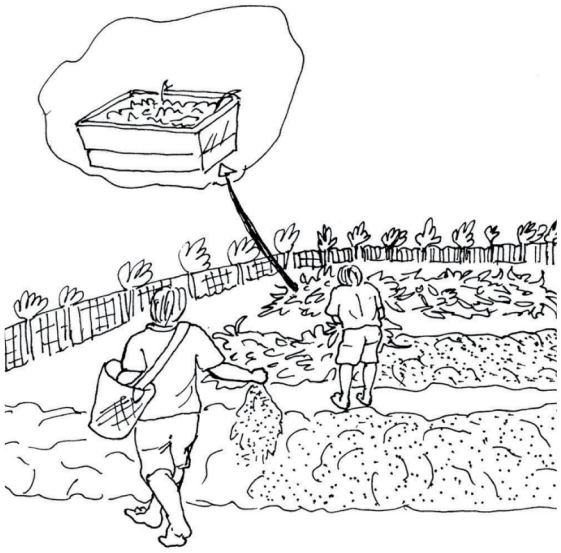
pH balance solutions

The BEST solution for acidic or alkaline soil is to increase the organic matter content.

This is achieved by using mulch, compost, manure and green manure crops. Over time these techniques make the pH neutral, and allow more nutrients to stay in the soil and be available for plants.

OTHER SOLUTIONS FOR ACIDIC SOIL

- Ash from wood fires (**do not use ash from burnt rubbish**) can be spread on the ground. Use no more than 1 kg (a large bucket) per 30 m_2 each year. Do not burn grass or plant materials to make the ash because they are also very important for the pH balance.
- Crushed seashells provide lime to help balance the soil.
- Biochar raises the pH level of acidic soil.
- For large areas crushed dolomite (a calcium-magnesium limestone) can be used. Dolomite is better than lime because it contains the important element magnesium, and lime can burn plant roots. Both are expensive to buy and should only be used if pH tests are used first.



Using ash and compost to improve soil pH

Kilograms (kg) of dolomite needed to raise soil pH to 6.5 per 30 metres square

SOIL PH	SANDY SOIL	MIX SANDY/CLAY SOIL	CLAY SOIL
6.0	1 kg	1.5 kg	2 kg
5.5	2 kg	3 kg	4 kg
5.0	3 kg	4 kg	6.5 kg
4.5	3.5 kg	6.5 kg	9 kg
4.0	4 kg	8 kg	10.5 kg

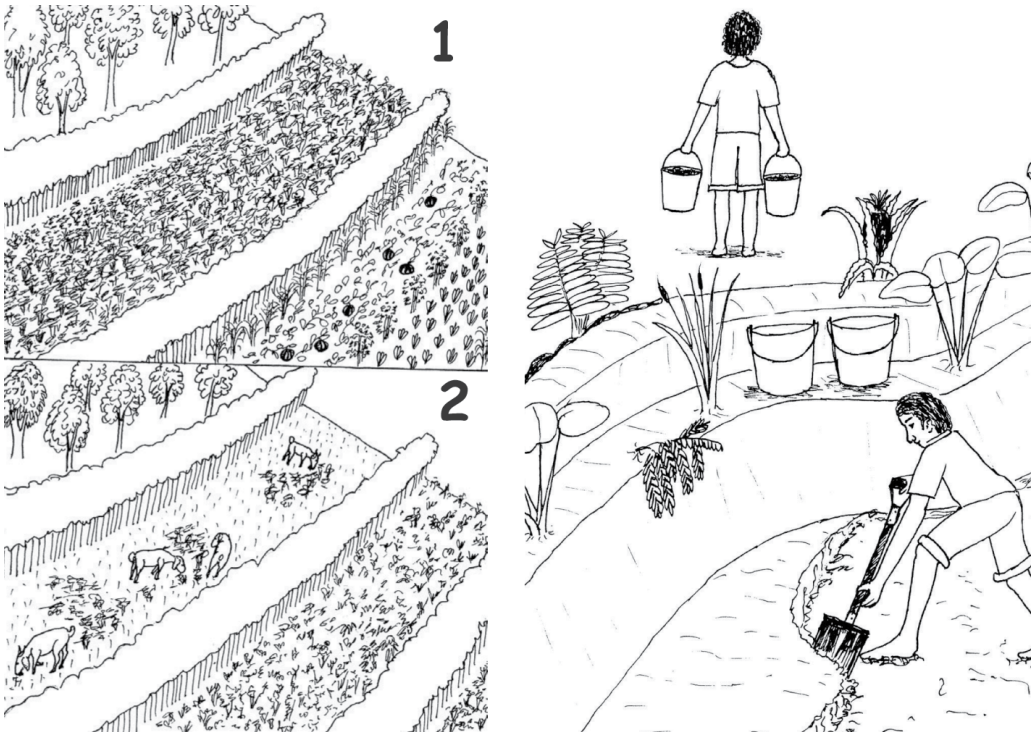
OTHER SOLUTIONS FOR ALKALINE SOIL

- Use 6 kg of compost per square metre to lower soil pH by one unit. (Example: 8.5 down to 7.5). This does not have to be applied all at once. Always cover the compost with mulch.
- Use 3 L of liquid compost, already mixed 1:10 with water, per square metre. (It is not as effective as compost, but it still gives good results.)
- Use 2 kg of manure per square metre to lower the soil pH by one unit.
- Iron sulphate or elemental sulphur can be used, but they are expensive to buy and pH tests need to be used first.

Kilograms (kg) of iron sulphate or elemental sulphur needed to lower pH by one unit

- 2 kg of iron sulphate per 30 m_2 of sand/mix soil, or 8 kg of iron sulphate per 30 m_2 of clay soil
- 300 g of elemental sulphur per 30 m_2 of sand/mix soil or 1 kg of elemental sulphur per 30 m_2 of clay soil

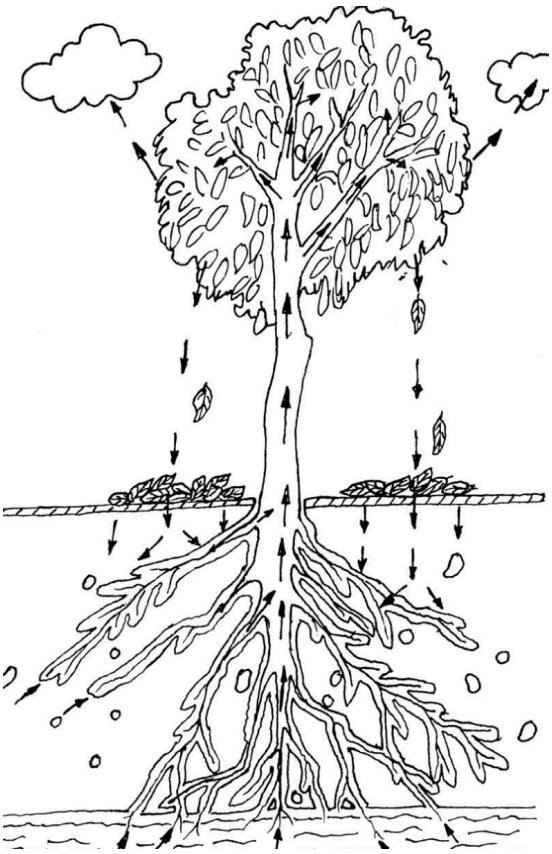
A mix of sandy and clay soil is also called loam soil.



Improving soil pH with green manure and soil from a fish pond

Nutrient cycles

All plants use different nutrients in different amounts to grow. The plants store many of these nutrients in the leaves, fruit, stems, trunks and roots as they grow. Trees and deep-rooted plants use their roots to bring up minerals (nutrients from rock) from deep down in the soil, as they are often not present in topsoil. Trees also draw up water from deep in the ground, acting like a big pump.



Tree cycling water and nutrients

Some of the nutrients are used in a tree's growth, and some are used making the fruit or seeds or are stored in the fruit or seeds. This is the same for vegetables and smaller plants. These nutrients are lost from the system and need to be replaced.

A lot of nutrients can be recycled back into the soil by humans and animals, and in compost and mulch. The lost nutrients can be replaced using the soil improvement techniques explained later in the chapter.

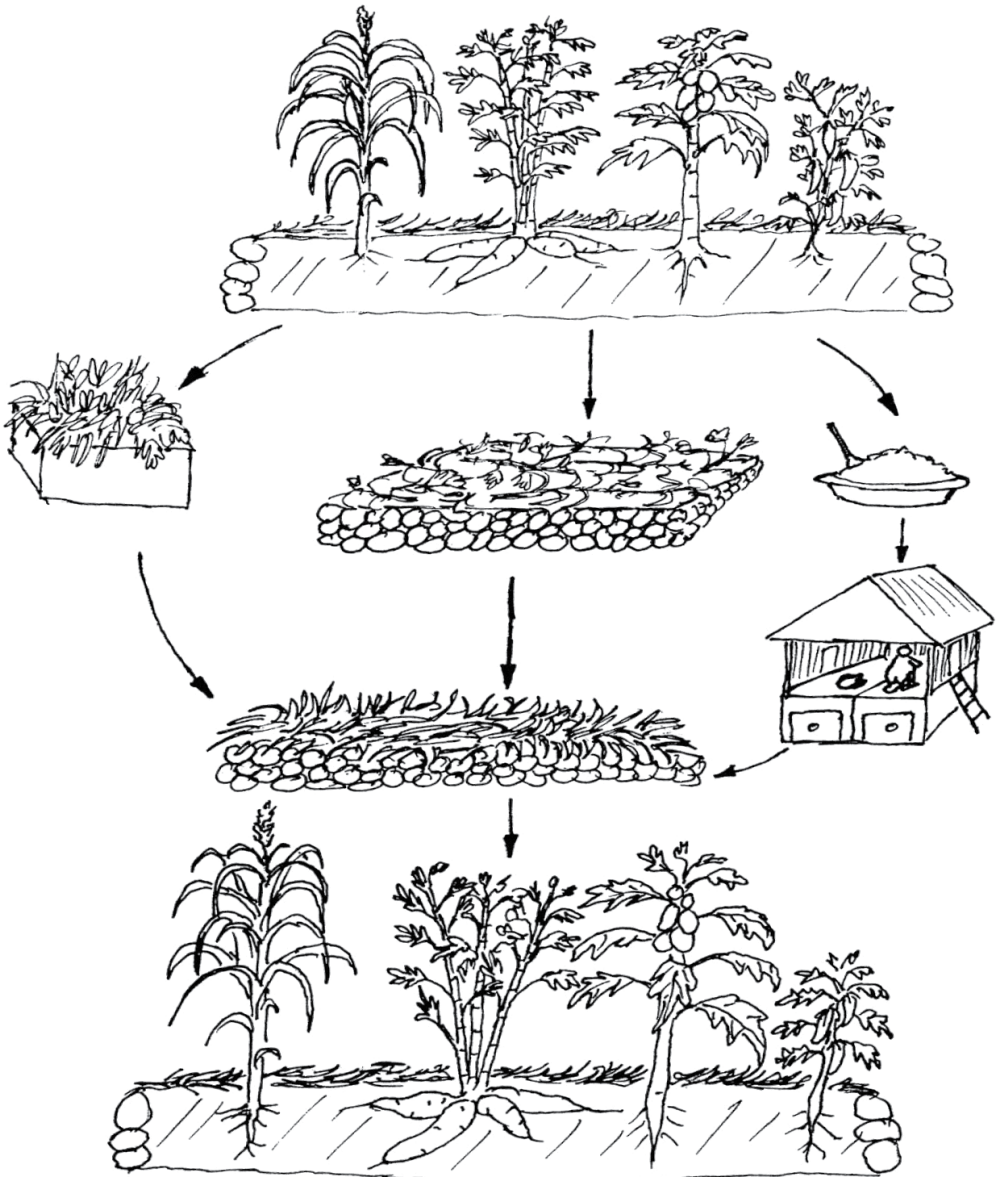
In tropical climates a lot of nutrients are stored in the trees, with only a little stored in the ground. Therefore, cutting down trees means nutrients are lost from the system. The land is only good for growing crops for one or two years, but then the soil becomes very poor.

At present there is far too much deforestation in tropical countries. In many countries there is very little forest remaining so all that is left needs to be preserved. A lot of land is bare and needs reforestation, which then helps to restore the supply of nutrients. Farming and fertilising techniques need to focus on improving the land with techniques that increase and cycle nutrients rather than preparing agriculture land by annual burning of weeds and plants.

Burning the land is a very big problem and removes valuable nutrients from the system. Each time the land or plant material is burned, the nutrients stored in the plants are lost. This occurs both on agricultural land and in forests. The ash provides just a small amount of potassium and other minerals, but often it is blown away by wind or washed away by rain before it enters the soil.

The ash is easily replaced by putting the ash from cooking fires into liquid compost or compost heaps. If there is a lot of ash from cooking fires, it can be spread lightly on the ground as well. However, the amount of nutrients lost from burning the forests is far greater than the small benefit gained from the ash. Plant material, unlike the ash, is not easily replaced.

Remember, the more you recycle nutrients back into your system and the more you improve the soil the less you need outside resources!



Nutrient deficiencies

A lot of soils are deficient in nutrients. Sometimes the soil is deficient in a lot of nutrients, and sometimes just one or two nutrients are missing.

When the soil is sandy, rain can leach nutrients from the soil. When the soil is waterlogged, nutrients can convert to gas and be lost. Therefore, creating good soil immediately reduces soil deficiency problems and stops them recurring.

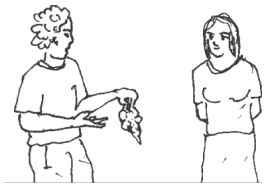
Like humans, plants also need a range of vitamins and minerals to grow well. If the nutrients are not available, the plants are smaller, produce less, and are more susceptible to drought, pests and diseases. Plants show distinctive signs when they are missing a specific nutrient.

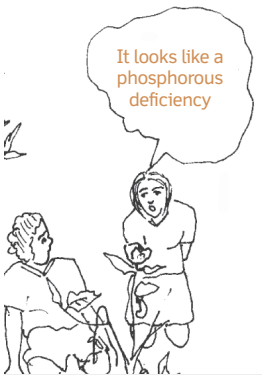
Nutrient Deficiency Table

MISSING NUTRIENT	PLANT CHARACTERISTICS	NATURAL SOURCES OF MISSING NUTRIENTS
Nitrogen	• Yellowing and paleness of all leaves and new growth • Not much new growth • Early maturing and small sized fruit or flower	Bird manure, cow manure and urine, human urine, green (fresh) grass
Potassium	• Leaves are smaller and darker in colour than normal. • Older leaves can be a blue/purple colour with yellow edges. • Plant growth is slow.	Ash (from kitchen fires), banana leaves and stems
Phosphorus	• Fruit size is small and poorly coloured. • Burnt leaf edges have a purple, blue or reddish colour underneath and yellowing of veins of old leaves.	Bird manure, ash (from burnt animal bones), ground animal bones
Magnesium	• Edges of leaves turn yellow or have yellow spots, but veins stay green. • Brown spots on leaves can also occur. • Old leaves drop early off trees.	Epsom salts (magnesium sulphate): two teaspoons dissolved in five litres of water. Other sources: fish remains, crushed dolomite, animal manures
Sulphur	• Dull colour of all leaves • New shoots develop poorly	Organic matter and animal manure
Calcium	• New leaves and new shoots grow badly and are underdeveloped. • Fruit growth can be unusual.	Crushed egg shells, gypsum
Micro-nutrients	• There are many different micro-nutrients that plants need. • Symptoms of problems are different too.	Seaweed, bamboo leaves, rock dust

This leaf is not healthy.

What is wrong with this eggplant leaf?





Problem solved!

It is not the answer to add a basic chemical fertiliser if plants are sick or not producing well. This approach can do more harm than good. It is much better to try to identify the exact deficiencies and problems. The solution is more effective and cheaper.

Magnesium and calcium balance

Magnesium and calcium are two elements you need in good soil.

They also need to be in balance with each other. If there is imbalance, other nutrients can be "locked up" and unavailable to plants even when they are in the soil. What are the types of rocks under the soil? Where there is a lot of limestone and old coral the soil generally has a lot of calcium therefore, you may need to add magnesium. In non-limestone areas usually there is a calcium deficiency.

See the nutrient deficiency table in the previous section and in the natural nutrient sources section next for some natural sources of calcium and magnesium.

Soil nutrients - the plant builders

Plants require nutrients, minerals and trace elements in a form that is always available to use.

If the land is under cultivation, nutrients are being used and must be replaced. You should not only be replacing the lost nutrients but also slowly improving the soil so that it can hold more nutrients and water to increase future production. Organic natural fertilisers can be used regularly and applied before, during and after cropping.

Nutrients that are not consumed are stored in the soil for later use. Organic fertilisers improve the soil in the short and long term. It is always better to compost manure before using it as fertiliser. If manure is fresh, especially bird manure, it can burn small plants and young vegetables. Also, the nutrients are not yet available in the right form for the plants to use. Composting materials concentrates the nutrients and makes them available for plant use. It is the same as humans trying to eat uncooked rice, corn or cassava!!

There are many different composting methods: we explain the basic ideas. Over time, with research and by experimenting, you will find out what works best for your land, climate and needs. This could be new or traditional techniques, or a combination of both.

Natural nutrient sources

Most nutrients can be replaced by using compost, liquid compost and mulch. This is the best and most balanced method.

Sometimes a specific nutrient or nutrients are not in the ground or in the plants owing to erosion, deforestation or poor soil. The nutrient needs to be reintroduced into the system, and added again once or twice a year for the best results. The new nutrients should be recycled in the system as much as possible to reduce the need for further inputs.

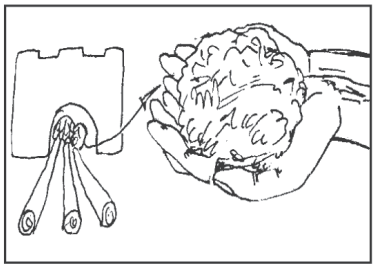
Plant trees, grasses and shrubs to provide constant resources for organic fertilisers and soil nutrients. This is part of a permaculture garden or farm design.

Different ways to introduce new nutrients

- Seaweed contains many nutrients. A lot of nutrients from the land are washed out to sea with water and eroded soil. Seaweed uses and stores many nutrients and, therefore, can replace nutrients that are lost. It is a good source of micronutrients.
- Add high concentration manure – bat, pigeon, chicken and duck manure. Bat and pigeon manure are best, but all are great because the manure comes from food sources such as insects, seeds, tree leaves, etc. The manure contains many more trace elements and concentrated nutrients.

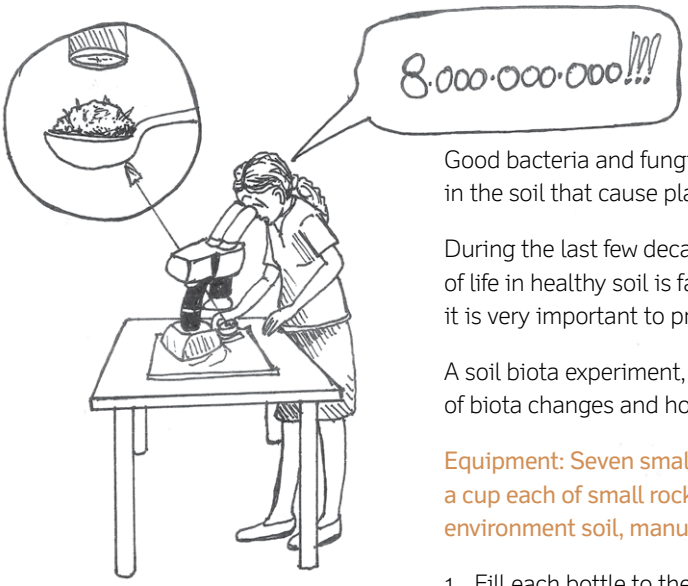
Collecting seaweed

- Animal bones, carcasses and innards are highly concentrated forms of nutrients and provide a lot of micronutrients. They can be part of solid compost, put in liquid compost or buried under new fruit trees.
- Banana trunks and leaves provide good potassium as mulch or in compost.
- Burnt bone ash adds phosphorus.
- Biochar (Activated charcoal) provides carbon, as well as storing other nutrients.
- Bring in mulch or manure from other areas.
- Grow legume trees to add nitrogen to the soil.
- Wood ash from cooking fires provides potassium.
- The soil from the bottom of a well-managed fish pond contains a lot of nutrients. Read Aquaculture (**Ch 18**).
- Use ponds to make mulch. Water plants are excellent for taking and storing all types of excess nutrients from water, including waste water from houses.
- Trees leaves provide different minerals because trees bring them up from deep in the ground. Some of these minerals are stored in the leaves.
- Bamboo and casuarina leaves accumulate silica, an important mineral: bamboo ash is good as well.
- Use a specific micronutrient fertiliser (preferably made from seaweed and rock dust) to replace the nutrients. This is an unusual fertiliser: the usual fertilisers, including urea, will not replace rare nutrients.
- Add rock dust (crushed gravel) to your soil at one big handful per square metre. It will improve soil drainage and slowly release minerals for years.
- Agricultural gypsum, used to loosen heavy clay soils, contains about 23% calcium and 18% sulphur.
- Coffee grounds (the waste powder from making coffee) are rich in organic matter and trace elements. They also stimulate the growth of some types of vegetables, especially root crops. Mix coffee grounds in rows where you plant carrots, beetroot or potatoes to improve results. Be careful if you have acidic soil because coffee grounds are also good for balancing alkaline soils and for plants that like acidic soil.



Biota - the soil builders

Biota: worms, insects, micro-organisms, fungi, bacteria provide the soil structure and are your workers in the soil. They build good soil, turn humus into plant food and help provide all the nutrients the plants need in the form that is best for them.



The number of biota in a teaspoon of healthy living soil!

Good bacteria and fungi also help to control bad bacteria and fungi in the soil that cause plant diseases.

During the last few decades, soil scientists have found that the range of life in healthy soil is far more extensive than they first thought, and it is very important to protect it.

A soil biota experiment, which is great for kids, shows how the amounts of biota changes and how much the biota actually "breathes".

Equipment: Seven small water bottles; seven same sized balloons; a cup each of small rocks, clay, sand, garden soil, forest or natural environment soil, manure and compost.

1. Fill each bottle to the same height (half full is good).
2. Attach a balloon to each open bottle.
3. Wait and see what happens: it does not take long!

Importance of worms in soil

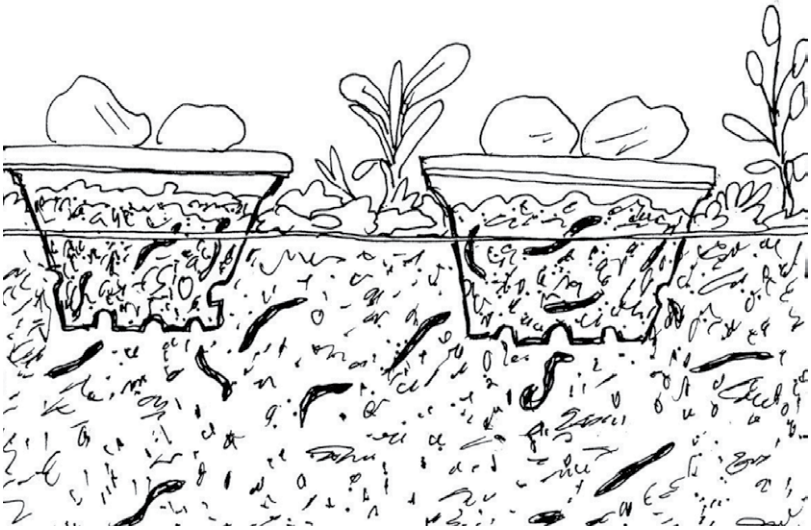
Worms are your best friends in the garden!

These are different worms from those that make people and animals sick. Soil worms are a good indicator of healthy soil: the more worms you have, the healthier your soil is.

Worms eat and excrete soil. As the soil passes through their bodies, the humus in the soil is changed into nutrients and the soil is improved. **In a year each worm eats and excretes many tonnes of soil!!! Every year each worm produces 150 baby worms.**

They continuously:

- Turn organic matter into nutrients that plants can use.
- Dig and add air to the soil.
- Improve soil structure and water drainage.
- Bring up nutrients from deep in the soil to supply the plant roots with food.



Worm farm buckets and worms in the soil

All they need is mulch, compost, manure and moisture. Insects, such as ants, termites and some beetles, perform similar functions to worms and help create good soil, but ants and termites can sometimes create problems, and none of them work as fast as worms!

Beware: Pesticides and some chemical fertilisers can kill the worms in your soil.

Organic soil improvement strategies

All of these strategies focus on providing the complete range of nutrients required as well as the soil biota to maintain and build healthy soil and turn the organic fertiliser and organic matter (OM) into a ready-to-use plant food.

The nutrient supply and biota population are connected in many ways. The results are that your soil improves and increases each year, and your plants are very happy!

Micro-organism activators

Micro-organism activators create and provide soil biota for the soil. These are essential for improving the soil structure and quality. It is a liquid that can be added to any compost or liquid compost or poured straight into the soil, and contains trillions of micro-organisms!

Micro-organism activators:

- Speed up the composting process.
- Improve the quality of the natural fertiliser.
- Improve the nutrient availability.
- Improve all aspects of soil quality.

It is possible to buy Effective Micro-organism (EM) from agricultural shops. It does work but some studies have shown that it can reduce local micro-organism population. It is better and cheaper to make your own from local bacteria.

How to make micro-organism activators

There are many recipes for micro-organism activators, and the ingredients depend on what you have available. They are easy to make, and once you have a full bottle you can continuously use that to make new bottles.

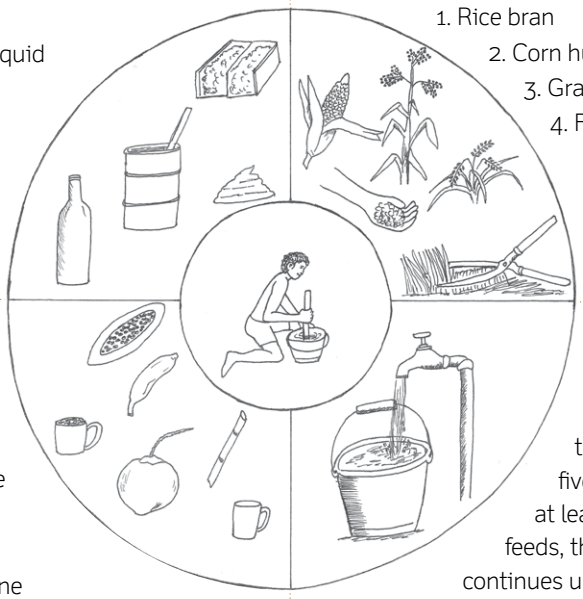
You need three main ingredients. For each ingredient use some from each source, if possible, for the best results. This recipe is for one bucket.

Sources of good local bacteria, a big handful or a cup, depending if it is solid or liquid:

- Healthy soil
- Home-made compost or liquid compost
- Fresh cow manure
- Already made micro-organism activator that has been kept in a sealed bottle

Food for the bacteria—four handfuls in total—choose one or mix together:

1. Rice bran
2. Corn husks
3. Grain husks (e.g. sorghum)
4. Finely chopped fresh grass



Sugar for the bacteria (choose one or a mix):

- Molasses (a cup)
- Overripe fruit (two or three pieces, 0.5–1 kg)
- Natural sugar from palm, coconut or liquid sugar cane juice (a cup)
- Coconut water (a coconut)

(If you are mixing the sugars, only use half a cup of the molasses and natural sugar.)

Add these ingredients into a 10 L bucket, fill it with water until it is three-quarters full, stir it for five minutes, and leave it for at least a day. As the bacteria feeds, they quickly multiply. This continues until all the sugar and food is eaten.

An activator recipe from Timor-Leste:

1. After cutting a banana stalk, the section attached to the base starts rotting in the middle.
2. Take a big handful of the rotting stalk, mix and crush it in a bowl with two big spoons of natural sugar.
3. Strain the liquid into a bottle straight away.
4. Use after one or two days.

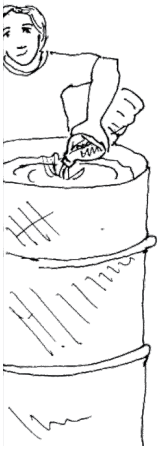
There are many other recipes and methods: use the recipe that works best for you with the resources you have.

How to use micro-organism activators

Liquid compost: add a bucket of micro-organism activators to liquid compost.

Fast compost: add a bucket to a small compost and two buckets to a large compost.

Slow compost and mulch resource heaps: add a quarter of a bucket per metre, using a zig-zag pattern.



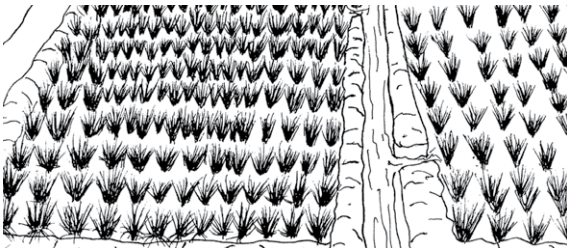
Liquid compost

Garden bed

Slow compost and mulch

Soil: spread the micro-organism activators over any agricultural land and around fruit trees. Only a small amount is needed because the micro-organisms will multiply. Use a cup every metre for family gardens and a cup every two or three metres for larger crops, using a zig-zag pattern. Make sure you have mulch on the soil as well.

Rice paddies: add a few buckets into the irrigation water. Micro-organism activators are much more effective when combined with the System of Rice Intensification (SRI) Technique that is explained in Sustainable agriculture (**Ch 13**).



Compost toilets: add a quarter of a bucket every month to reduce the smell and improve the composting process.

To save the micro-organism activators in sealed plastic bottles, wait until the bacteria have almost stopped growing. You can see this because they will have stopped producing foam or froth on top. If you store it too early, the bottles may explode! If you wait too long, the bacteria may die. This liquid can be used to make more micro-organism activator.

DANGER: Micro-organisms in the soil, including good bacteria and fungi, are **damaged or destroyed by burning, chemical pesticides, chemical fungicides and some inorganic fertilisers**.

Biochar - activated charcoal

What is biochar?

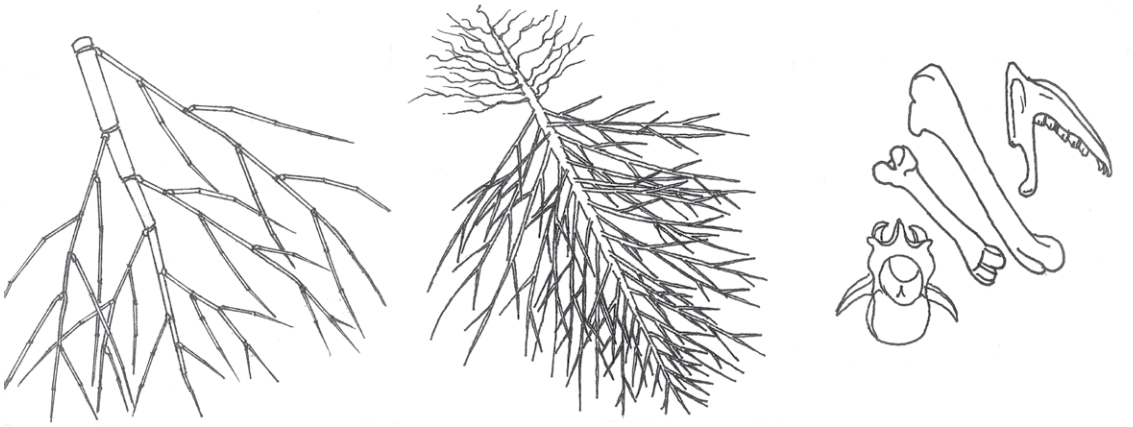
Biochar is an activated and specially made charcoal. It has been used by some cultures to improve soil for thousands of years, such as the Mayan farmers of southern Mexico. Its benefits are only being rediscovered now.

It is especially important for tropical soils that suffer from nutrient loss each wet season.

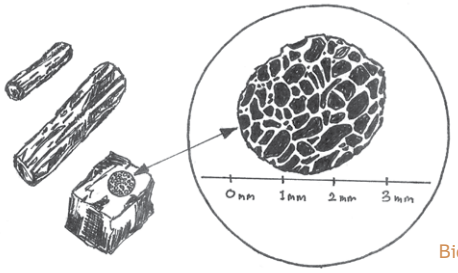
Biochar stays active in the soil for hundreds or thousands of years, so your children and their children and their children will get the benefits too! You only need to apply it once or in small amounts over time, but because it lasts so long you also need to be careful not to add too much. Only use it in the right situation and create the best conditions for it to work well.

Biochar is a stable form of charcoal produced from heating natural organic materials in a high temperature (300°C to 700°C), low oxygen process known as **pyrolysis**. It can be produced from a wide range of materials including wood, bamboo, crop waste, animal bones, bark, woody weeds and manure. NEVER use wood or other materials treated with chemicals to make biochar.

- Charcoal from cooking or open fires can be used but the quality is much lower than biochar made from pyrolysis and provides a lot fewer benefits. This is because charcoal from cooking fires has much less surface area and breaks down in the soil much faster.
- Pyrolysis systems can be small and simple, using metal tins or drums, medium level or even very large and complex systems for large-scale production. They can even be a hole in the ground!
- Biochar made of wood, bamboo or woody organic matter adds carbon to the soil but is not a source of nutrients. Its purpose is not to fertilise your plants or soil, but to create the opportunities for it to be fertile. The most sustainable materials to use are bamboo, weeds that have woody stems and animal bones. If biochar is made of manure or bones, its immediate fertilising value is higher, but it does not last as long.



Ingredients for making biochar



Biochar close-up

ACTIVATING BIOCHAR

The biochar acts as a storage house for nutrients, micro-organisms and biota. They stay in the biochar, even in the wet season.

It is easy to activate the biochar before you add it to the soil. Simply soak it for a few days in a micro-organism activator or liquid compost. It soaks up the nutrients, micro-organisms, fungi and bacteria for you to add to your soil. The easiest method is to use old cloth or cloth sack filled with biochar and a few rocks for weight. Tie the sack to the top of the liquid container.

Think of biochar as a warehouse for storing and spreading the biota and nutrients that your soil and plants need.

Benefits

There are many benefits from using biochar which are continuous and long lasting. It can take three years or more to see the full benefits, but the effects start happening immediately.

FOOD PRODUCTION:

- It increases the size and quality of the yield, and these increase over time.
- For trees it significantly improves the fruit size and tree growth.
- It promotes healthy root growth.

SOIL QUALITY AND NUTRIENTS:

- Biochar reduces soil density; this helps in reducing soil compaction.
- Soil structure for all types of soil improves quickly, especially sandy soil.
- It increases the OM and carbon content in soil.
- Carbon to nitrogen (C:N) ratios in compost and soil are better balanced.
- Nutrients lost in the wet season are greatly reduced, especially in sandy soil.
- Biochar balances the pH in acidic soil and could replace lime or dolomite for raising soil pH. It is alkaline and, therefore, must be used with care on alkaline soil.
- Biochar holds and stores nutrients for the plants, which significantly and permanently increases the soil's ability to hold nutrients–the soil Cation Exchange Capacity (CEC).
- Biochar reduces the amount of fertiliser needed each year.
- It is especially good for rebuilding poor soil.

BIOTA AND MICRO-ORGANISMS:

- Biochar creates a habitat for soil biota and micro-organisms.
- The amount of soil biota the soil can hold and use is greatly increased.
- Wet season loss of soil biota is greatly reduced.

Crops in unhealthy soil

Crops in healthy living soil'

WATER EFFICIENCY:

- Biochar improves the soil structure and increases the amount of air in the soil. Therefore, the amount of water the soil holds increases too. For sandy soil it can double or even triple water storage capacity!
- It reduces water use and costs owing to improved water holding capacity.
- It reduces water runoff during high rainfall.

CLIMATE CHANGE AND HEALTHY ENVIRONMENTS:

- Biochar is organic and has no chemicals. (NEVER use wood, or any other material, that has been treated with chemicals to make biochar.)
- Carbon is stored in the ground which reduces the amount of carbon that goes into the air and reduces CO_2 pollution. If millions of farmers use biochar and other methods to store carbon in the soil there will be a big reduction in the severity of climate change and the problems that come from it.
- Less water is needed for the plants, so there is less stress on springs, rivers and underground water supplies.
- The soil is better and the plants are healthier, resulting in fewer pest attacks, and less use of fertilisers and natural pesticides.
- When bamboo is used, the improvement for the environment is even bigger.

Dangers

There is still a lot of research needed to show how biochar works. It is important to get as much information as you can before you use it. So far, on a general level, research shows:

- Too much biochar can reduce the benefits and even create problems. Remember that biochar can last for hundreds of years so it is better to start with small amounts and set a maximum amount that you apply.
- For soil with a high pH (alkaline) it is not yet clear whether biochar makes the pH worse or better, but it is clear that the benefits are fewer than for acidic or neutral pH soil.
- Biochar can also soak up and store poisons from chemical pesticides, fungicides and herbicides and nutrients from chemical fertilisers, as well as from strong natural pesticides. This can create huge problems:
- It slowly releases these poisons which kill all of the good micro-organisms.
- It reduces the effectiveness of the chemical pesticides, fungicides and herbicides.
- If it stores nutrients from chemical fertilisers that are high in nitrogen, it can impact nutrient balance in the soil and soil pH.

It is already clear that biochar works much better with organic and sustainable agriculture, and most likely has a negative impact if used with chemicals and even overuse of natural pesticides.

If you are transitioning from chemical to organic farming, it is advised to wait until the chemicals are no longer in your soil before you apply biochar. This can take a year or more, depending on what has been used and how the soil is improved. The more organic matter and beneficial micro-organisms you add, the faster this process occurs.

How to make biochar

The method is to create a space where the materials can burn at hot a temperature with as little oxygen as possible (pyrolysis). The materials MUST be dry before burning them or a lot of energy is wasted removing the water from the material before it burns.

Biochar can be made in any sized container, even small metal tins, or in a hole in the ground. Charcoal from cooking fires can be collected and used but the quality is much lower than biochar made from pyrolysis and provides many fewer benefits.

BIOCHAR PIT

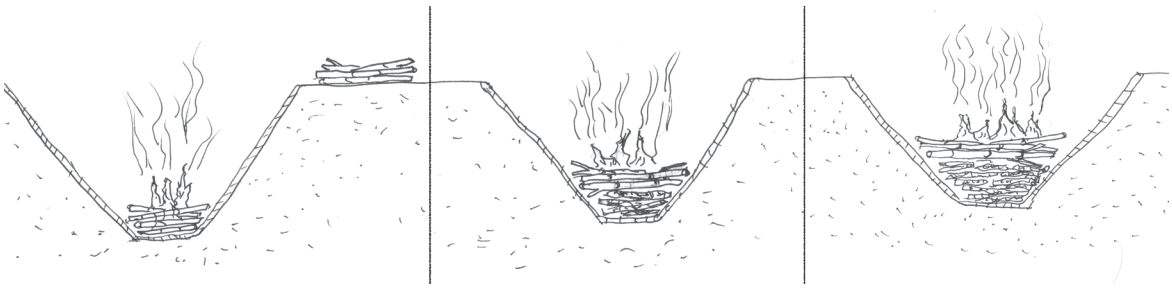
This is a very cheap, simple and effective method for producing biochar. It takes some time to prepare the materials, but produces a lot of biochar and keeps you warm during cold nights too.

Preparing the pit and the materials

1. Dig a cone or "V" shaped pit, either 1 m wide in diameter and 75 cm deep in the middle, or with a 1.5 m diameter and 1 m deep in the middle.
2. If the ground is mostly sand, add a 2 cm thick clay wall to the pit. This keeps the heat in and the wood burns faster.
3. Prepare the dry bamboo or wood for burning.
4. Add the materials in layers over time, and plan for ten layers with each two pieces thick.
5. Cut the bamboo or wood into various sizes and sort them into like-sized pieces, so they create layers in the cone and burn at the same rate.
6. Fit the bottom layer to the bottom of the cone or "V" shape, and the top layer to the top of the pit. Therefore, the bottom layer has pieces approximately 10 cm in length, the next layer 20 cm in length, the third layer 30 cm, and so on. The lengths will vary depending on the size of your pit.

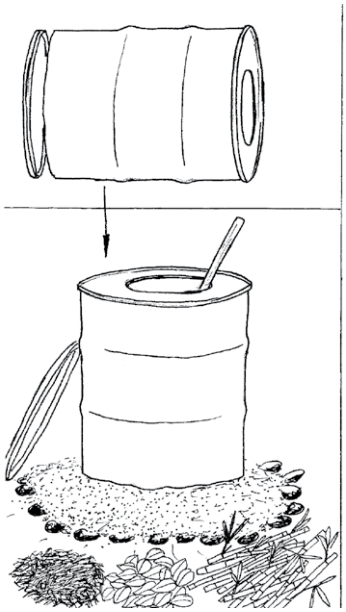
Making biochar

1. Collect some dry grass and small sticks in the bottom of the pit, and start a small fire.
2. Add the first layer of bamboo or dry wood, two pieces thick, (as explained above) with the smallest pieces on the bottom.
3. Let the first layer burn until you see white ash beginning to form. Immediately add the next layer of bamboo/wood.
4. As this next layer starts to burn, the pit's shape draws oxygen from below and the bamboo/wood underneath stops burning. When the new layer starts to produce white ash, add the next layer immediately.
5. Continue this process with each layer. Make sure each layer is two pieces thick, with small pieces on the bottom and larger pieces on top. As the new layers are added, the wood below them stops burning because there is no oxygen. Keep going until you reach ground level or run out of wood. It does not work above ground level.
6. When the top layer starts producing white ash, use water to put the fire out completely. Leave it until the next day to collect your pit full of biochar. Do not forget to activate it before use.



Adding materials step-by-step to the biochar pit

BIOCHAR DRUM



Step 1: Cut the bottom off of a 44 gallon drum. Wash it well with soap to remove any petrol or oil and leave it in the sun for a few days. Turn it over and cut a small circle, 20 cm wide, in the middle of the other end. Make sure any sharp edges are banged inwards. This end is the top.

Step 2: Fill the drum with the dry materials including wood, bamboo, crop waste, animal bones, bark, woody weeds and manure. Add as many bigger pieces as possible because the biochar mostly comes from this.

Step 3: Burn the material, and put it out with water as soon as the flames start to reduce.

Step 4: Collect and dry the biochar. Make sure you also use the ash from the drum for gardens and composts as it is high quality.

This is a simple biochar drum. A 2-drum system with one drum inside the other is much more efficient and produces much higher quality biochar. See reference chapter for more information.

BIOCHAR COOKING STOVES

There are now stoves that cook your food and create biochar at the same time! A normal stove or oven produces much better quality charcoal than an open cooking fire, and uses much less wood too. Read more in Food, health and nutrition (**Ch 8**). A stove designed specifically for making biochar produces the best quality charcoal. Read the reference section for more information.

LARGE BIOCHAR PRODUCTION

Biochar can be made on a medium or large scale. This requires expensive equipment, but it produces a lot of biochar once it is set up. To make this happen you can work with/on:

- Local cooperatives
- Government community projects
- Businesses
- Development projects with a non-governmental organisation (NGO) or UN agency

For more information and techniques, check the reference chapter for websites or look for demonstrations in your area.

How to use biochar

Biochar stays in your soil for much longer than you will live, for hundreds and even thousands of years! Therefore, if you are only producing small amounts, you add it to your soil slowly and the amount increases over time.

ACTIVATING BIOCHAR

Make a liquid compost or micro-organism activator that has lots of nutrients and good bacteria. Add the biochar and leave it for two to three days. Always activate your biochar before you use it.

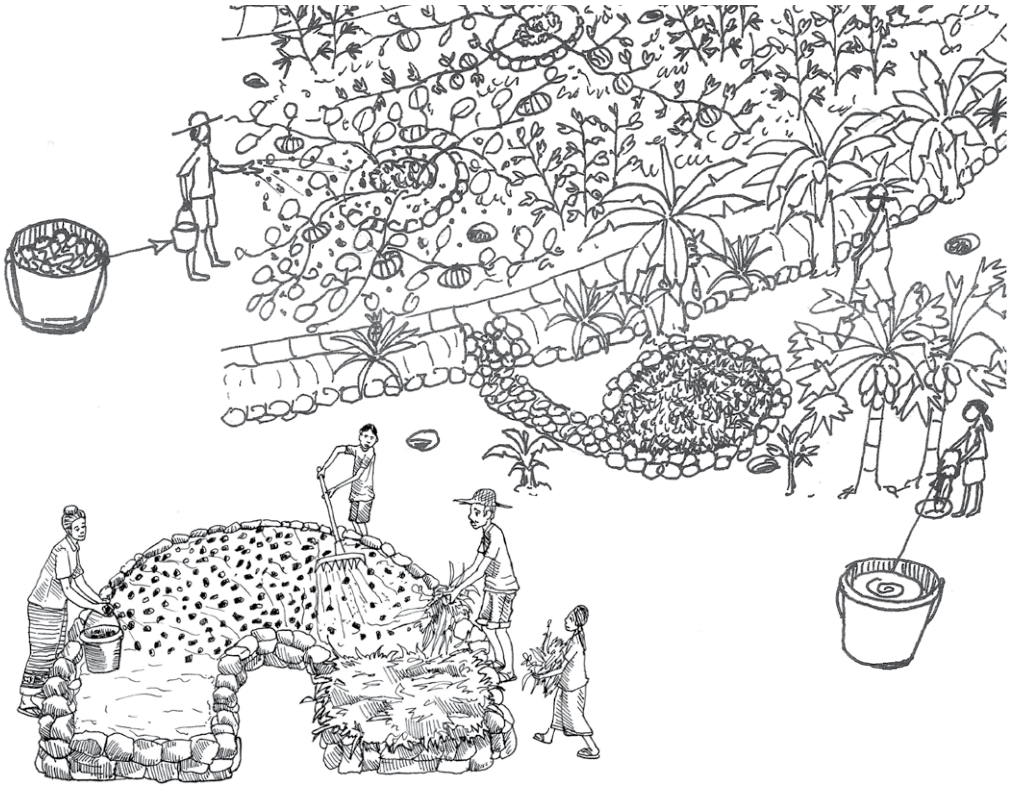
COMPOST

Add two buckets of dry biochar to slow or quick compost. The biochar activates in the compost by soaking up nutrients, biota and moisture, as well as adding carbon. If you add biochar, do not add ash or the compost could become too alkaline. This method adds biochar to your gardens, agricultural land and fruit trees through your compost.

FAMILY GARDENS AND SUSTAINABLE AGRICULTURE

Biochar works best if it is lightly dug into the topsoil. It still works if you just spread it on top, but the micro-organisms decrease. For both methods add compost or dry manure, if possible, and ALWAYS put mulch on top.

- A bucket (10 L size) of dry biochar is about 1 kg, half a 10 L bucket of wet activated biochar is about 1 kg.
- A quarter to half a bucket of wet activated biochar per m2 is a good rate according to current research.
- For sandy and acidic soil use half to one bucket of wet activated biochar per m_2.



For sustainable agriculture

You can add the biochar in one complete application or slowly over time. It depends on how much you can make or access. The goal is to add about half a 10 L bucket of activated biochar per square metre.

For example: 1000m_2 of land needs 500 buckets. Therefore:

- Add 500 buckets

OR

- Each year for 5 years add 100 buckets

OR

- Each year for 10 years add 50 buckets.

Always spread it evenly over the whole area.

You can:

- Dig it into the top layer of soil and add mulch (this is better but takes more time),

OR

- Leave it on top but cover it with compost/manure and mulch immediately.

FRUIT TREES AND PRODUCTIVE TREES

The positive effects of adding biochar are likely to be greater in orchards with lower soil fertility and in regions with limited water availability. However, all trees will produce more and grow larger no matter what the soil is or the amounts of organic fertiliser used.

For young trees: half to one bucket of wet activated biochar is a good rate according to current research. For sandy and acidic soil use one bucket of wet activated biochar per young tree. Add the same amount in five years' time, when the tree is mature.

For mature trees: add one to two buckets of wet activated biochar. For sandy and acidic soil use two buckets per mature tree.

Apply the activated biochar to the root zone, and to the feeding zone under the outer leaves. Biochar breaks down very slowly so you only need to add a small amount every five years: 25% of the original amount used at the most. As research on biochar is only new, reapplication times and amounts are not yet fully confirmed.

USING BIOCHAR AS ANIMAL BEDDING

You can use biochar as the bottom layer of animal bedding. It soaks up excess liquid, ties up nutrients, and limits nitrogen loss. You can also add some rock dust (such as dust from granite or basalt) to your biochar. A 10 L bucket of biochar/rock dust mix is enough. ALWAYS add a thick layer of other bedding material on top of it, such as straw, wood chips or sawdust.

Liquid compost

Liquid compost is easy to prepare and is very useful for everything from nurseries, small gardens, large crops, rice paddies, fruit trees and other tree crops.

It is a good way to make organic fertiliser, rich in nutrients and biota, from small amounts of manure and other ingredients. It is excellent for supplying nutrients and micro-organisms over large gardens and farms, and a much more efficient use of materials, time and space than solid compost. Always use it with mulch, especially if you do not use solid compost.

Liquid compost can be made very strong so it can be mixed with water and, therefore, it lasts longer. You can make it in any sized container – from a bucket to a steel drum, the larger the better. It can be stored anywhere on the farm where the fertiliser is needed. It must be near a water supply, in the shade, next to where you will use it, but not too close to the house.

There are many, many different recipes for liquid compost: we have included a basic complete recipe here but find one or more which best suit your needs. Often they are made without manure and are still very valuable for improving plant growth and health.

Standard liquid compost

Step 1:

Cut the lid off an oil drum using an axe and hammer. Be sure to hit down any sharp edges.

Step 2:

Clean inside the drum thoroughly with detergent and water, and leave it in the sun for two to three days. This is to make sure you remove all the old oil or petrol.

Step 3:

Fill the container a quarter full with manure. Fresh manure has more nutrients than dry manure and contains billions of important bacteria. Mix different types of manure for a better result as different manure has different nutrients.

Manure from birds - pigeons, bats, chickens and ducks is the strongest, followed by pig, goat, cow and horse manure. Therefore, you need less bird manure than animal manure.

Step 4:

Fill the next quarter of the drum with grass, plant materials, weeds, leaves and seaweed. Weeds with long thick tap roots (the main long central root) bring up minerals from the ground and store some of them in the plant. These weeds are good to add to liquid composts. Running weeds, such as couch and kikuyu, and problem weed seeds, are easily killed and turned into useful fertiliser.

Always cut up your ingredients as much as possible to make decomposition faster. Do not use branches because they take a long time to break down and take up valuable space. They also make stirring your liquid compost difficult.

Seaweed has valuable minerals and nutrients that are important for plants and which are sometimes lacking from soil, manure and plant compost materials. The seaweed MUST first be washed with fresh water to remove the salt because the salt badly affects soil quality and plant growth. Only collect fresh seaweed because dry seaweed stores the salt as it dries.

The best leaves to use are moringa, sweet leaf, and legume trees and shrubs. Don't use leaves from Eucalypts, plants with white sap or plants that are natural pesticides. Read the plants for compost and liquid compost section in composts for more information.

Step 5:

Add compost activators. These ingredients contain trillions of biota that turn the ingredients into liquid compost and make the nutrients ready for the plants to use. As the biota "eats" the ingredients, it continues to multiply. Putting biota in the soil is just as important as giving nutrients to the plants. The biota can come from:

- Two shovels of healthy, living soil or
- Two shovels of compost or
- Two shovels of very fresh cow manure or
- One bucket of micro-organism activator (the best)

To help this process even more, add a cup of molasses or sugar and a shovel of rice husks.

Step 6:

Fill the container to 10 cm below the top with water.

Step 7:

Other ingredients that can be added are:

- Half to one shovel of ash, to add minerals and potassium–bamboo ash is best
- One or two shovels of soil from fishponds

Step 8:

Cover the container to keep animals out and stop rain from diluting the fertiliser.

Step 9:

Stir the container with a long stick for five to ten minutes every day for two weeks, then reduce to twice a week for two weeks. This MUST be done to add oxygen to the fertiliser which helps to break down the ingredients. Stirring to add oxygen also reduces the smell!

The longer you leave the liquid compost, the better it gets. It is recommended to wait at least a month. Leaving it for extra time means the liquid compost is less likely to burn the plants but is still rich in nutrients.

Some recipes say to wait three months until using it. One technique is to put a thick layer of dry grass stalks/straw on top, half in and half above the liquid, and wait for a couple of months. The straw acts as an oxygen pathway and reduces the smell.

Step 10:

Mix one part liquid compost with twenty parts water (1:20) and use it. This advice must be followed because if the fertiliser is not diluted properly, the plant leaves and roots could be burned from too many nutrients at once. Young plants are more sensitive than older, established plants.

You can use the fertiliser every two weeks to a month for vegetables, small plants and trees, giving them the same amount as you would when watering.

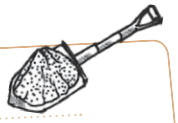
Once every one to two months is good for established fruit trees.

METHODS FOR CONTINUAL USE

1. When the liquid is finished, tip out most of the remaining solids onto compost and start again. Leave a small amount to provide micro-organisms for the next liquid compost. It is good to use the liquid compost within six months as the number of biota reduces over time if you do not add new ingredients. Use two or three containers so you can make one per month and always have one ready to use, and one or two containers of liquid compost sitting.

OR

2. Keep adding a few new ingredients. When the liquid compost is half full remove some of the existing solids and add them to dry compost. Then fill a quarter of the container with fresh ingredients and a quarter more water. Stir regularly. This creates a continuous liquid compost drum.



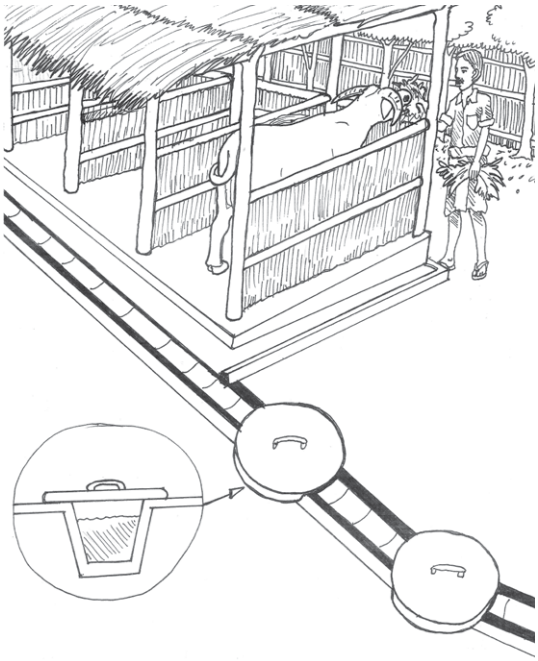
SMART IDEAS:

- You can use a spray pack to spray plant leaves with liquid compost mix in the early morning.
- Match the liquid compost with your needs and use different ingredients for different crops: tree leaves for trees, grass for grass crops and weeds with big tap roots for root crops.

Fermented cow urine liquid compost

Cow urine is very high in nitrogen and contains many other trace elements. It is proven to increase growth rates and, if prepared properly, it can also act as a bacteria activator.

Collect cow urine from the floor in the cow yard where the cows are housed at night. A cement floor is easiest to collect urine and keep clean for the cows to be healthy. Collecting cow urine from compacted earth is also possible, but the top layer of dirt must be removed and replaced regularly. The floor needs to have a very slight slope so the urine can run away easily. Build a cement drain leading either to a cement catchment pit or a drum placed in a hole. Protect the catchment and pit/drum from rain and water runoff.

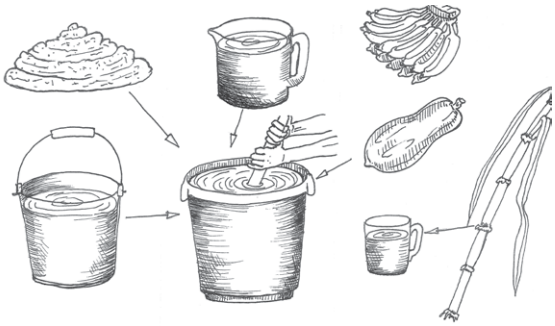


There are many different recipes for cow urine liquid compost. All of them require:

- Cow urine
- Micro-organism activator (fresh cow manure, rennet, yoghurt, compost, etc.)
- Sugar: molasses, sugar cane juice, over ripe fruit
- Oxygen, stirred in by hand or using a pump. An excellent system is to pump the liquid from a drum to the top of some steps, with the liquid pouring down the steps back into the drum. This adds a lot of oxygen quickly.

Some recipes add neem leaves, moringa leaves and other herbs for extra nutrients and pest control. Here is one recipe:

- Mix 1 kg of fresh cow dung, 1 L of cow urine and six overripe bananas or a small overripe papaya or 500 ml of sugar cane juice in 10 L of water.
- Stir this solution two or three times each day for three days.
- Start using the liquid compost from the fourth day by adding ten parts water to one part concentrated solution (10:1).



MORINGA LIQUID FERTILISER

The following is based on information from and with thanks to Trees for Life
www.treesforlife.org/our-work/our-initiatives/moringa

The incredible moringa tree can be made into many, many products, including liquid fertiliser. This provides many benefits to crops and is a great small business idea for a cooperative or farmers group. The main equipment needed is a simple juice extractor and a spray pack.

- Set aside an area to grow moringa just for liquid fertiliser. Plant the moringa close together, three hands apart, in rows that are also three hands apart. After every sixth row leave a metre-wide path for access.
- The plants can grow and produce with no irrigation and only small amounts of fertiliser, and can be harvested four times a year. With some irrigation and regular fertiliser, the plants can be harvested eight times a year. They will produce for many years.
- The plants are harvested 20 cm above the base, using all of the leaves and green shoots. The green tops grow back again for the next harvest.
- Extract juice from the moringa harvest straight away or the amount of liquid collected reduces quickly.
- Dilute with thirty parts water to one part moringa juice (30:1).
- Spray approximately 20–25 ml onto the leaves of each plant. This does not have to be exact: give each plant a spray as you walk through the crop. Spray in the early morning or late afternoon for maximum results.
- Use the dry remains that are left over as high quality compost material or chicken food.

Benefits – plants:

- Grow quicker when young
- Are stronger and more resistant to pests and disease
- Live longer
- Have heavier roots, stems and leaves
- Produce more and larger fruit
- Increase in yield from 20–35%

Plots of moringa can be planted on a rotation schedule, so there is an ongoing harvest for a fertiliser supply.

Harvesting moringa

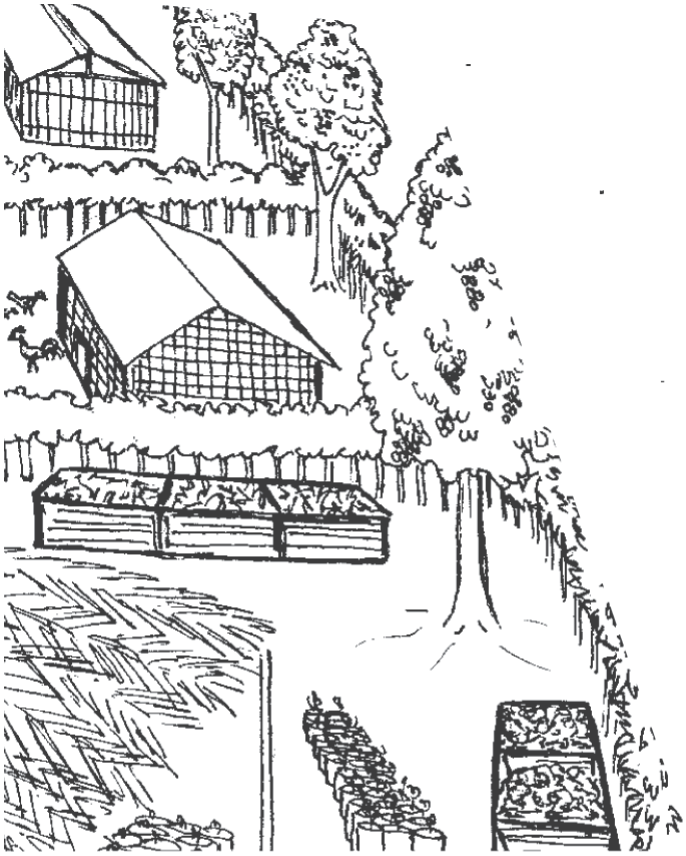
Extracting moringa juice

Spraying moringa liquid fertiliser

Compost

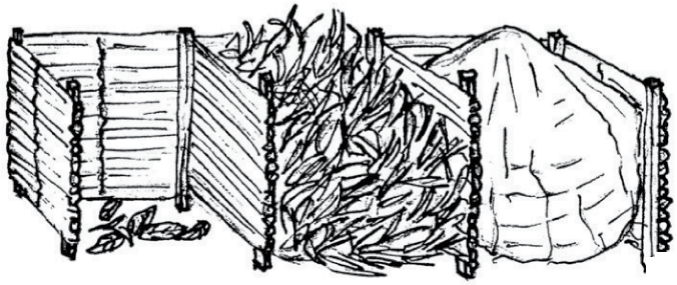
Compost is broken down organic matter that is added at the bases of fruit trees, on garden beds or around vegetable crops to provide extra nutrients. It is also called solid compost or dry compost. Compost is made by soil biota that breaks down organic matter into a concentrated, rich nutrient source.

Its main components are carbon and nitrogen. Dry plant material is mostly carbon and a small amount of nitrogen; green plant material has a mix of carbon and nitrogen, and the amount of nitrogen depends on the plant, and; manure is mostly nitrogen and a small amount of carbon.



Compost also contains many other nutrients, minerals, trace elements and soil biota. Compost not only provides your vegetables and fruit with nutrients but it also improves the soil structure. This is very important for future crops. There are many different ways to make compost heaps, from a simple mix of rice husks and cow manure to lots of different materials. It depends on what materials are available. Experiment for yourself.

Plants also benefit because the micro-organisms, fungi and bacteria in compost reduce the amount of damaging soil diseases and provide resistance to disease for plants, especially when the compost is prepared properly.



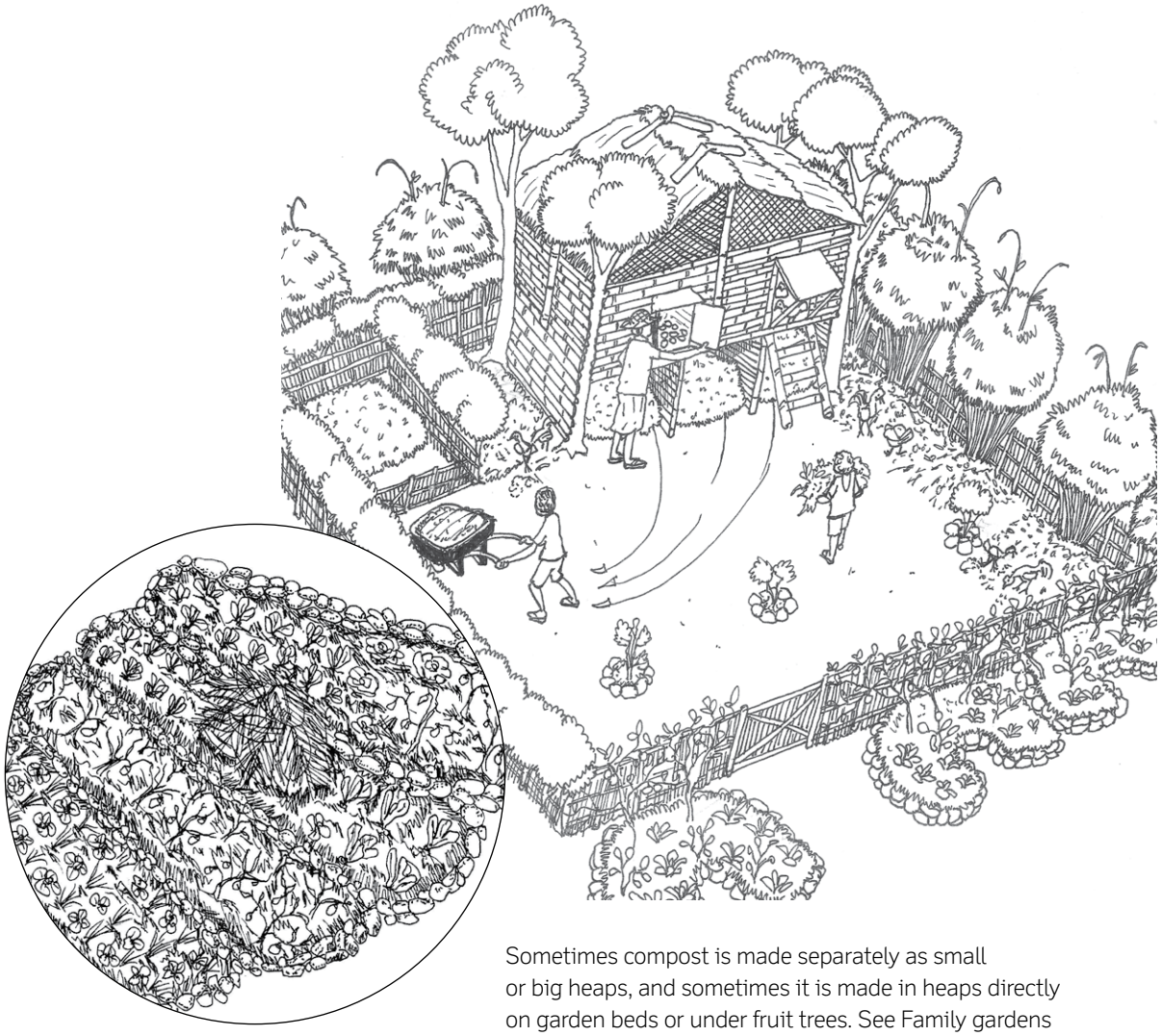
Composting is also a great way to make use of weeds. *Tithonia diversifolia* (Mexican Sunflower) and *Eichhornia crassipes* (Common Water Hyacinth) are examples of land and water weeds that can be continually composted. Water weeds are especially good, as they are nutrient rich and by using them you also help control them.

Coffee grounds are rich in organic matter an d trace elements and good for compost. Coffee grounds are acidic so add some ash as well to balance the acidity.

Compost should be made near the place that you want to use it. On a big farm, you can make many compost sites. Important ideas:

- Create a resource storage area next to the compost for the compost materials.
- Plant living fences/compost material trees nearby.
- A good place is between the animal house and family garden/farm/orchard.

Compost bays (place for making the compost) can be made out of many different materials, depending on what you have available. It is usually closed on three sides and open on one side to make access much easier. Make three compost bays side by side so you have several types of compost and always have one ready or nearly ready. A bay for quick compost should be about 1 m wide, 1 m long and 1 m high, while those for slow compost heaps can be much larger, depending on the space you have.



Sometimes compost is made separately as small or big heaps, and sometimes it is made in heaps directly on garden beds or under fruit trees. See Family gardens (**Ch 10**) and Trees (**Ch 15**) for details.

SMART IDEAS:

- Build your compost bay by creating a living fence for the walls. Use trees that are high value compost material, such as legume trees or moringa. The compost feeds the trees and the trees feed the compost.
- Even better is to build a small chicken or rabbit house above the compost bays, using the trees as poles. With a wire mesh floor the manure falls straight through onto the compost heap!

Plants for compost and liquid compost

GOOD PLANT	WHY
Moringa	Very high nutrient content, breaks down quickly, grows quickly, drought tolerant, can continually be cut and regrown
Sweet leaf	Very high nutrient content, breaks down quickly, grows quickly, drought tolerant, can continually be cut and regrown
Water plants: water hyacinth, water spinach, water cress, duck weed	Very high nutrient content, break down quickly, grow very quickly, can regularly harvest
Legume trees	Very high nutrient content, break down quickly, grow quickly, drought tolerant, can continually be cut and regrown
Legume shrubs	Very high nutrient content, break down quickly, grow quickly, drought tolerant, can continually be cut and regrown
Grass	High in nitrogen when fresh (green), good carbon for compost when dry (brown), can be regularly harvested (perennial grass)
Bamboo and casuarina	Bamboo and casuarina leaves contain silica. Silica makes plants stronger and helps the water to move through plants more easily, which prevents moulds and fungus from growing.
Comfrey (high altitude tropics and sub-tropics)	Very high nutrient content, breaks down quickly, compost activator, can easily be propagated and regularly harvested
Weeds: *Tithonia diversifolia* (Mexican sunflower), cow pea, purslane, etc.	Common and good compost material, incredibly productive as biomass, mulch, compost material, soil improver. **Do not burn it, use it!**!
General trees	Good source of nutrients, especially minerals
Seaweed	Great source of minerals and micro-nutrients, use fresh and wash first to remove salt

Be careful not to introduce plant pests, especially into natural water catchments and rivers!

BAD PLANT	WHY
Plants with white sap	Often toxic or poisonous, take a long time to break down
Plants that are traditionally used as poisons or pesticides	Toxic and poisonous for the biota in compost and soil, potentially harmful to people using it
Lemon grass (only if used too much)	Contains oils which can suppress growth.
Weed bulbs, bad weed seeds and running weeds like kykuyu, couch grass and nut grass	They can spread if they are not properly treated. Some are good in liquid composts, or if they are dried first.
Eucalypts	High content of anti-bacterial oil - potentially harmful to soil and compost bacteria, leaves take a long time to break down

Quick compost

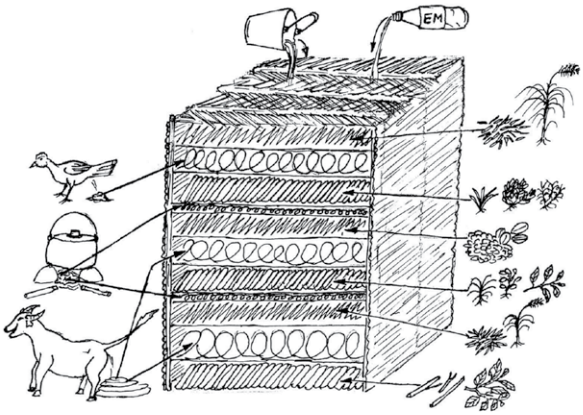
There are hundreds of different compost recipes and all will work if you:

- Achieve a good balance between carbon and nitrogen.
- Add nutrient rich ingredients.
- Add lots of good bacteria to break the material down quickly.
- Add the right amount of water.
- Make sure there is plenty of air in the compost (for oxygen).

A COMPLETE QUICK DRY COMPOST RECIPE

Ingredients:

- You can use many different materials: manure, grass, weeds, water plants, leaves, seaweed, soil, rice and coffee husks, wood ash, dead animals (mice, rats, fish, chicken, etc.), urine, feathers, human and animal hair, and any other natural materials you can find. You can even use small amounts of torn up paper and cardboard.
- Try to mix about one-third dry (brown) leaves, dried weeds, coffee and rice husks, one-third manure and about one-third fresh (green) leaves, seaweed, water plants, weeds. This mix does not need to be exact.
- Add half a bucket of wood/bamboo ash and two cups of lime powder (which is very useful but not essential).



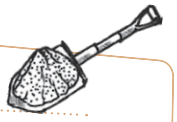
Compost layers

- Use smaller amounts of bird manure, such as bat, pigeon, chicken and duck, and larger amounts of animal manure, such as cow, horse, pig or goat.
- Use fresh manure if possible. If the manure is dry it is good to soak it in water first. This improves the composting process a lot. Soak all of the dry (brown) materials in water if possible. Then use this water for watering the compost when it is finished.
- Scraps from the kitchen should not be used in open composts because they attract rats. They should be fed to animals and turned into manure.

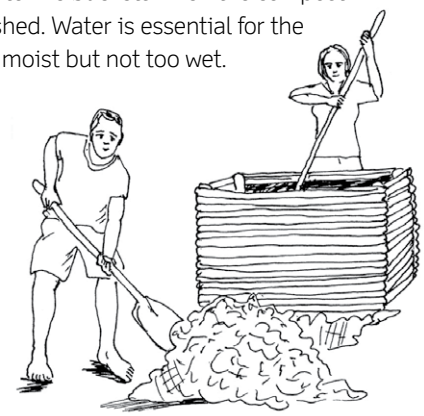
Activators and water:

- Add a bucket of micro-organism activator during the composting process. This is essential for creating fast decomposition, especially for smaller heaps of compost. See the micro-organism activators section in this chapter for recipes.
- Add small amounts of healthy soil, compost from old compost heaps and ash throughout the compost. One bucket of each is enough: bamboo ash is best because it is pH neutral.
- Add water twice during the compost construction. First slowly add four to five buckets when the compost is half made, and slowly add another four to five buckets when it is finished. Water is essential for the composting process, but do not use too much. The compost should be moist but not too wet.

SMART IDEA:



Putting slow compost next to a sick fruit tree helps revive the tree and provides compost too. A quick liquid compost booster also improves the tree and helps the compost to break down.



Method

Step 1:

A quick compost heap works best if it is made all at once. This means collecting all the materials first, and making the compost heap in layers.

Step 2:

The compost heap should be a minimum of 75 cm wide, 75 cm long and 75 cm high, but if you have the materials, 1 m wide, 1 m long and 1 m high is even better so that it can become hot enough to break down properly.

Step 3:

Always cut up or crush your ingredients as much as possible to make decomposition faster.

Step 4:

Add materials in layers of 5–10 cm starting with a 10 cm layer of small sticks and small branches. Then add the layers as follows–dry material/manure/wet material/dry material/manure/wet material, and so on. Sprinkle some ash and lime on the wet material layer each time. This technique of layers allows air to stay in the compost, which is VERY important. The compost must have good air flow to decompose properly. Spearing the heap once a week with a strong stick improves air flow.

Step 5:

Add the activators and water as needed.

Step 6:

Cover the compost to keep rain, direct sun and animals out and to keep the heat in. It can be covered with palm fronds, old material, old tarpaulin, banana skins or leaves, or a thick layer of dry leaves. Old tin roofing, if available, is excellent in the wet season for keeping rain off and animals out.

Step 7:

Following all the steps means the compost becomes very hot (65–68°C!), because the bacteria are very active, and it cooks itself into ready-to-use natural fertiliser and soil improver. It cools down again after two to three weeks.

Step 8:

The compost now needs to be turned out side in because the outer area does not get as hot and is yet not properly composted. Once you turn the compost, add two more buckets of water if needed and cover it again. The compost heap reheats and cooks for two more weeks.

Step 9:

It is then ready to use on the garden.

Small quick compost

You can make quick compost in small heaps on the ground and turn them every day or two.

Use the same ratio of ingredients as above, and use already-made compost and micro-organism activators to speed up the process. Add enough water every time you turn the compost to keep it moist. These small composts heaps can be ready in two weeks.

Slow compost

Slow compost takes a lot longer but you can continuously add to it.

It can be made in a compost bay or on the ground in a heap. You can make the compost just from plant materials, which takes a long time. This type of compost is not as nutrient rich but is still very good for improving the soil.

Slow compost works best if you:

- Achieve a balanced mix of about one-third manure and two-thirds plant material.
- Turn the compost occasionally.
- Add a bucket of micro-organism activator.
- Add small amounts of healthy soil and ash throughout the compost. One bucket of each is enough: bamboo ash is best because it is pH neutral.

The compost takes between three to six months to be ready, depending on what you make it from and how much attention you give. If you have space, you can make the first heap on the ground. Always add new materials on the same side, slowly turning the heap into a line or a "compost worm". After a time, you can use the ready compost from one end and keep adding new materials to the other end.

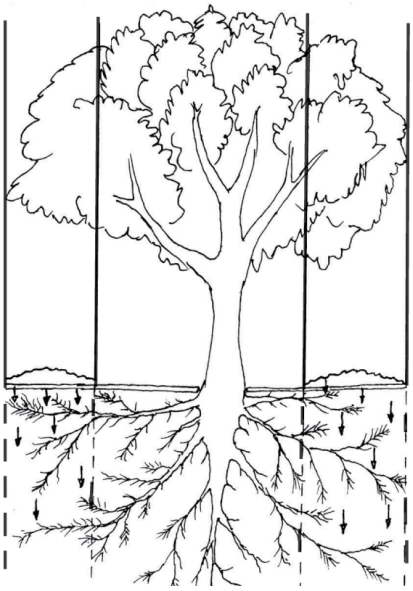
Animal house compost

You can make composts in bays, pits or big heaps directly from manure and urine collected from animal houses:

- Add lots of dried grass, weeds, rice and coffee husks to the animal houses to collect and absorb the urine and manure.
- Clean out the material and add to the compost every two weeks.
- Mix into the compost some fresh leaves, fresh grass and weeds (no seeds or problem weeds - read weed section in Family gardens (**Ch 10**).
- Add some soil, micro-organism activator or liquid manure to speed up the decomposition process and improve the result.

SMART IDEA:

For small animal houses with cement floors wash the urine and manure out daily via a small trench into a bucket. Add this to your slow compost or animal house compost.



Feeding zones

Using compost

Put compost on plots or beds two weeks before planting seedlings, or direct seeding of corn, beans, pumpkins and so on, to allow the nutrients and compost to infiltrate the soil.

Wait two weeks after planting the seedlings before adding more compost.

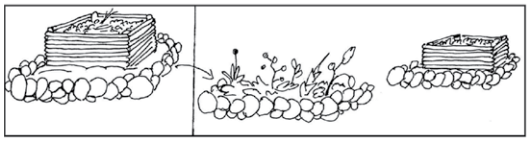
Use about two big handfuls for each seedling and four big handfuls for each mature vegetable. A layer of 3 cm over a whole garden area and around fruit trees is good.

The best place to put the compost for trees is directly under the outside leaves, under which the tree roots mostly feed, not around the tree trunk. This is the same for ALL fertiliser use. Do not let the compost touch the tree trunk because this can cause rot.

Always cover the compost with a mulch layer to protect the compost and improve the results.

SMART IDEAS:

- Start a new compost heap when one heap is half ready. This ensures a continuous supply of compost.
  Plan ahead.
- If the compost smells very sour, there is too much manure. If the plant material has not decomposed,
  you have not used enough manure or it is not moist enough.
- You can make compost on garden beds or next to fruit trees.
  This is called direct composting. Read Family gardens (**Ch 10**) and Trees (**Ch 15**) for details.



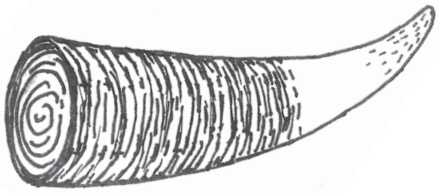
Biodynamic agriculture

Biodynamic agriculture is a type of organic agriculture that prepares and applies different liquids for fertilisers, plant and soil health, and pest and disease control.

There are also specific methods for compost making, soil preparation and when to plant, weed, make and apply composts, and other preparations. Solid compost and liquid compost require fresh cow manure.

Biodynamic agriculture comes from the temperate climates of Northern Europe, but it has been successfully tested and used in many tropical countries, especially India. Production levels and plant health are usually very high, and it uses local and/or organic resources. It fits very well into an integrated permaculture design.

Biodynamic agriculture is too big a big subject to explain properly here. Look in the reference chapter for various websites, and visit a biodynamic farm or education centre if there is one in your region.



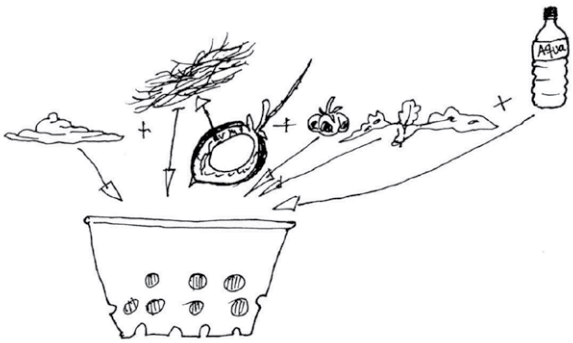
Worm farms

The early part of the chapter explained the benefits of worms. More worms mean better soil. There is a simple way to increase quickly the number of worms in your soil - a worm farm! There are two main types.

In-ground worm farm

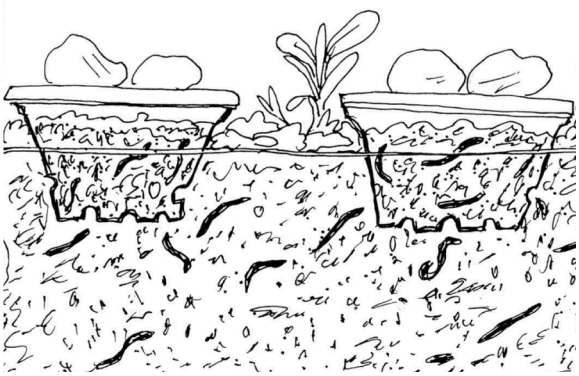
You need:

- An old bucket
- Coconut husk fibre
- Fresh cow or horse manure soaked in water
- Vegetable scraps from the kitchen
- A flat piece of wood or metal and a large rock



HOW TO MAKE AN IN-GROUND WORM FARM

- Make about ten large coin-sized holes in the bottom and sides of the bucket.
- Dig a hole in one of your garden beds so the bucket can fit in the hole with about a hand-width of the bucket above the soil.
- Fill the bucket with the coconut husk fibre, then the vegetable scraps, then the manure. Use about the same amount of each.
- Cover the bucket with the piece of wood or a lid so rats, dogs and other animals cannot enter, and put the large rock on top.



In-ground worm farms in a garden bed

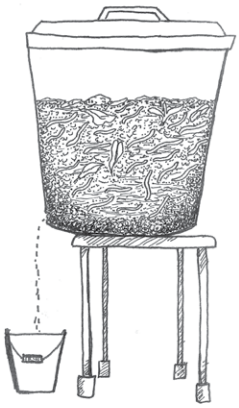
The worms come to eat the materials in the bucket and move back into the soil. Make sure the ingredients in the bucket are moist, especially in the dry season, and add more water when needed. Once every few months, clean out the nutrient-rich compost in the bottom of the bucket, and it to your garden, then add new materials to the bucket.

The more worm farms you make the better. They can be used for big or small gardens, fruit trees and even for rice paddies. The result will be many more worms, better soil and healthier plants!

Container worm farms

Container worm farms are separate from the ground.

The worms live in the container and are a different type from the worms in the earth. These worms do not live in the ground and the ground worms do not like living in worm farm containers. Container worm farms require more maintenance, but you get worm "juice", which is high quality liquid fertiliser, as well as worm "castings", which is rich, high quality compost. As the container worm farms are high maintenance, in-ground worm farms are recommended unless you have experience or know people who have. You also have to know who you can get the container worms from.



Container worm farm cross section

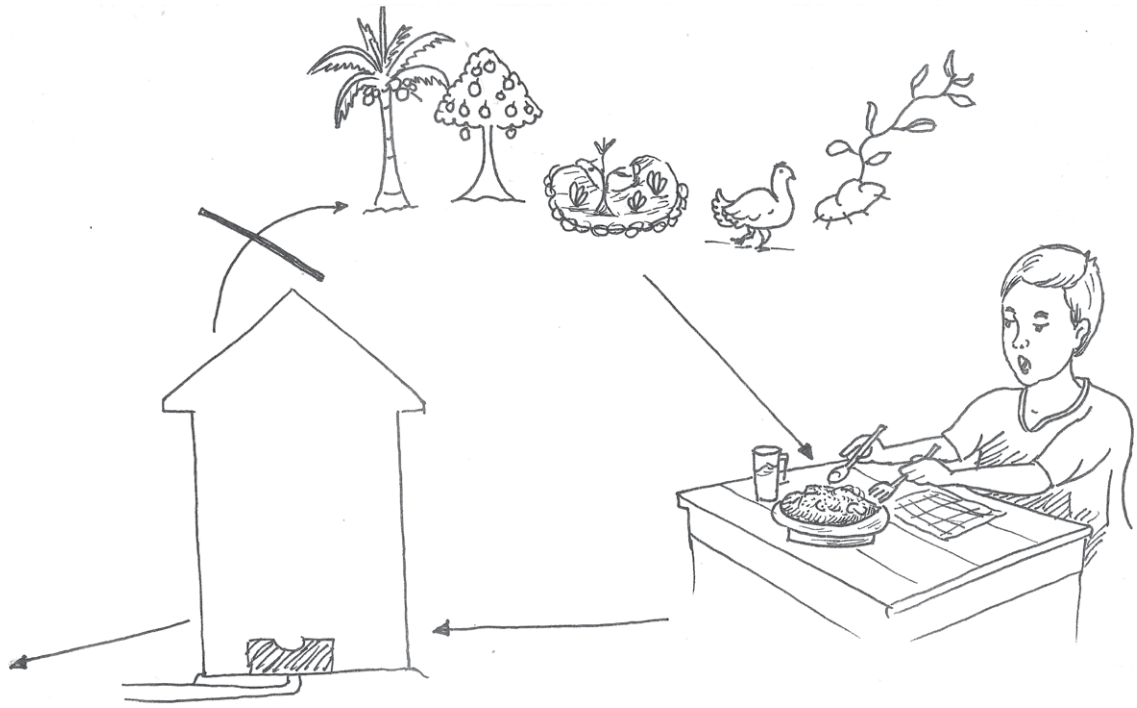
Good types of containers include old baths, wooden crates lined with plastic, big buckets, old drums (well washed and sun dried), etc. The container must have a hole in the bottom so the liquid can drain out.

Worms live in shredded coconut husk, old newspaper and cardboard, rice husks, etc. Worms eat kitchen scraps, fresh animal manure and green leaves. They do not like onions or citrus skins. Worms need water poured through the farm every two to three days, and must be well protected from rats, ants and flies. In the wet season they slow down and do not breed or eat much, but in the dry season they become more active. The container MUST be kept cool and in the shade. For more detailed information look in the reference chapter.

Humanure

"Humanure" is a term for human poo or waste that is composted and turned into valuable fertiliser for trees.

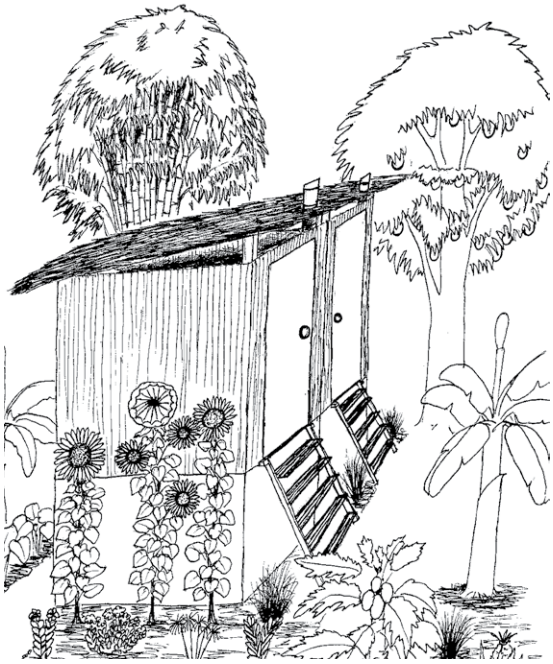
In many tropical countries touching or reusing human manure is not culturally appropriate and is considered bad. This is mostly because people get sick from it. The reality is that our methods for dealing with human manure look safe, but they are not and actually create health problems. Bacteria infected water constantly leaks from septic tanks into ground water, which contaminates tap water, and flows into rivers and oceans. Often people do not even use septic tanks.



Broken cycle and loss of nutrients

Composting toilets have been well tested: if people follow correct composting processes, they are absolutely safe.

Humans take a lot of nutrients from the ground via our food. When these nutrients are not put back into the ground via our urine and poo, we remove a large part of the natural nutrient cycle. We either do not replace it or replace it through chemical-based fertilisers that harm soil, contribute to climate change and cost a lot of money too! This situation must change if communities and countries are to become truly sustainable.



Solutions:

Compost toilets – there are many different types that suit any place and need. The compost created is safe, free of disease, and looks and smells just like compost. It is best to use the compost for fruit trees and other productive trees. Read Houses, water and energy (**Ch 7**) for detailed examples.

Town and city level – governments need to work towards cleaning and re-using town sewage on parks, sports fields, fruit trees, in forestry and reforestation. There are many successful examples of this already. Read more in Urban and community permaculture, (**Ch 4**).

Diluted human urine

This is an easy, free and continuous nutrient source and, unless it is reused, it is a wasted resource!

Urine is very high in nitrogen. If it is diluted in water (10–20% urine to 80–90% water), it makes an excellent fertiliser for fruit trees. Citrus trees respond especially well. It can also be added to banana/compost pits and compost heaps.

Urine is not recommended for vegetable gardens.

Mature fruit trees benefit from direct urination, but not in the same spot each time. Again, citrus trees benefit most. This is what we call direct nutrient recycling!

Organic and natural mulch

What is mulch?

In natural forests, leaves, rotting trees and other materials, animal manure and fungus all make a cover of mulch on the ground, LIKE A SKIN. This skin is continually being added to and continuously decomposing.

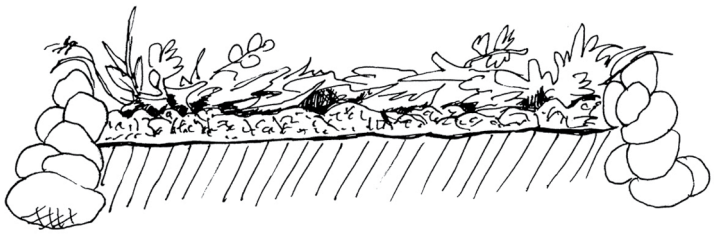
As it decomposes, the mulch provides nutrients and humus to the soil and thus to the plants. It also provides a continuous food supply for the soil biota. By copying nature, and growing, making and using mulch, you provide a skin for the soil. This skin is an important natural protection; it prevents the soil drying in the sun and eroding in the rain.

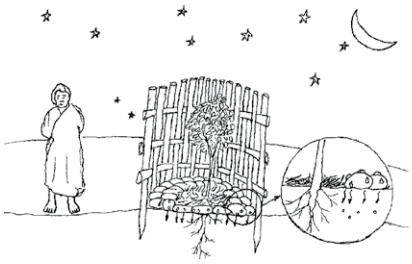
Mulch can be continually added to family gardens, agricultural land, orchards and tree crops, and reforestation trees.

Top with mulch, bottom no mulch

MULCH TYPES AND SOURCES

- **Top layer mulch**: Note – all materials must be very dry before use. Collect grass (without seed heads), leaves, rice and coffee husks, dry saw dust, bamboo leaves, ground coconut husks, seaweed (washed), most types of weeds (do not use weeds with seeds on them or bulb weeds), crop waste and water plants.
- **Bottom layer mulch**: Compost, dry aged manure, old newspaper and cardboard. They need a covering of top layer mulch.





- **Rocks can be used for reforestation trees and fruit trees** to help collect condensation in areas that get cold at night. See the 'reforestation trees' section in Trees (**Ch 15**).
- **Grow your own mulch**! All legumes, grass, water plants, many trees and other plants can be grown to produce mulch. Remember to think about multiple functions Mulch plants can also be animal fodder, windbreaks, fences, erosion control, soil improvers (legumes), trees for food and timber production, and more.
- **Use weeds!!** Some weeds make great mulch and can be used as mulch producers. Mexican Sunflower and Water Hyacinth are land and water weeds that can be continually harvested, dried and used for mulch, which helps to control them.
- **Bamboo leaves, washed seaweed, casuarina trees and water plants** (hyacinth, water cress and duck weed) are especially good because they contain much needed minerals and trace elements.

It is important to know the differences between dry (brown) mulch and fresh (green) mulch. Grass, leaves, bamboo leaves, seaweed and water plants dry out quickly, especially if they are cut into small pieces, so you can use them fresh or dry.

Fresh (green) mulch: All weeds should be well dried and cut up before being used as mulch. Some mulch materials, such as saw dust, and rice and coffee husks, absorb nitrogen as they dry out. Therefore, before using them it is best to:

- Dry them out for a month or two, OR
- Compost them, OR
- Use them on paths when they are fresh. They absorb water and nutrients from your raised beds. After three months you can put them on your beds as high quality mulch and put new fresh mulch on the paths.

Dry (brown) mulch: All mulch materials make excellent mulch when dry.

You can also create mulch using living plants, usually those that spread quickly, such as beans, pumpkins, etc. They cover the ground and act like mulch. Read the 'Cover crops - living mulch' section in Sustainable agriculture (**Ch 13**).

Be careful:

- Some plants contain strong oils and toxins and should either be used for mulch in small amounts or not at all. Examples are leaves that are traditionally used as poisons or pesticides and plants with lots of milky white sap. Lemon grass can also become a problem and should only be used in small amounts and not continuously.
- **Only organic, natural materials should be used. Plastic "mulch" is not mulch at all, and in tropical countries it destroys soil bacteria and harms the soil quality**. It is also not sustainable. Do not use cans, bottles, batteries, plastic bottles, plastic bags, plastic packaging or any other plastic rubbish.

Why use mulch?

Mulch provides valuable organic matter and nutrients for the soil.

- Mulch becomes humus, which improves the soil structure and aeration, and soil biota numbers increase.
- It increases the water storage capacity in the soil.
- A thick layer of mulch (6 cm deep or more) greatly reduces the amount of weeds. Lack of light prevents weed growth. Therefore, a lot less time is needed for removing weeds, and weeds that do grow are easier to remove. This helps a lot in larger vegetable gardens or agriculture, and for fruit trees and plant nurseries.
- Soil temperatures are moderated–the soil temperatures stay much cooler in hot temperatures and warmer in cold temperatures. More moderate temperatures mean happier plants and better growth. Remember it is the same for people!
- It balances soil pH levels.
- Soil becomes easier to dig and manage each season.
- Erosion is reduced.
- Plant yields increase.

THE MULCH EXPERIMENT – PROVING THE BENEFITS OF MULCH

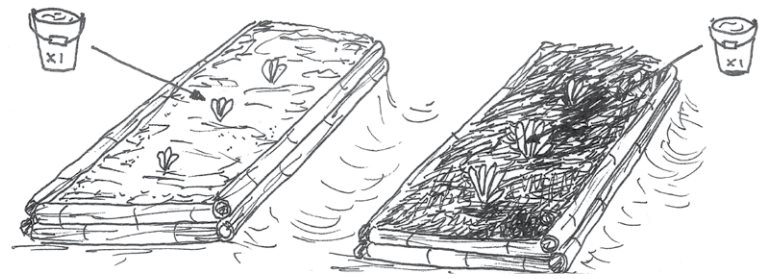
Try a simple mulch test and compare the difference after one day, three days, one week, two weeks, one month and three months. Experiment in the dry season and the wet season. Perform the experiment in three different areas for the best results.

You must:

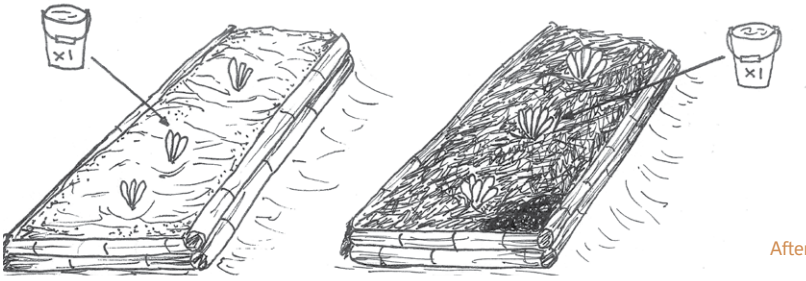
- Have the same sized plots.
- Have the same soil type within each experimental area. Different experiment areas can each have a different soil type.
- Use the same amount of water for each plot for accurate results.
- Use the same soil preparation for each area.
- Plant three test plants in each plot, the same types for both beds.

Look for differences in:

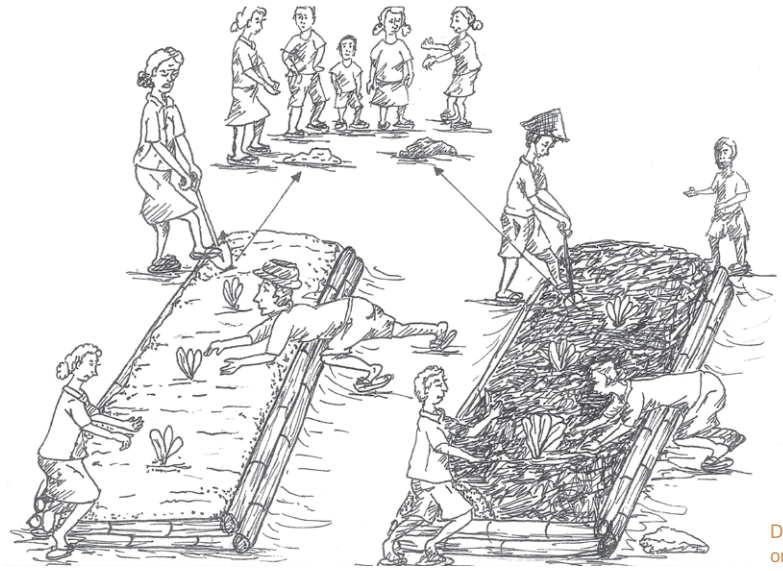
- Water content in the soil
- Soil temperature
- Soil biota close to the surface and further down in the soil (look very closely!)
- Number of weeds and how easy they are to remove
- Plant growth and health
- Soil structure (after one and three months as this takes more time to achieve)



Start experiment



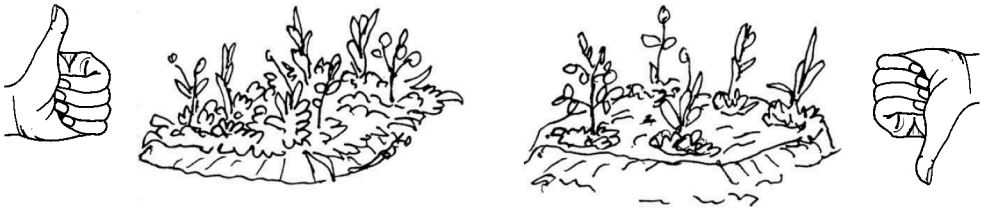
After one week



Discussing results after one month

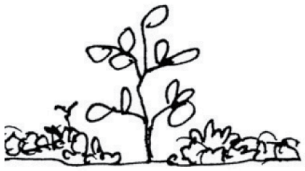
How to mulch

- Mulch continuously and as thickly as possible, 5–10 cm is great! For fruit trees 10–20 cm is even better!
- For seeds and seedlings it is easier to mulch first and then plant.
- Mulch the whole garden bed, not just around the vegetables or plants.

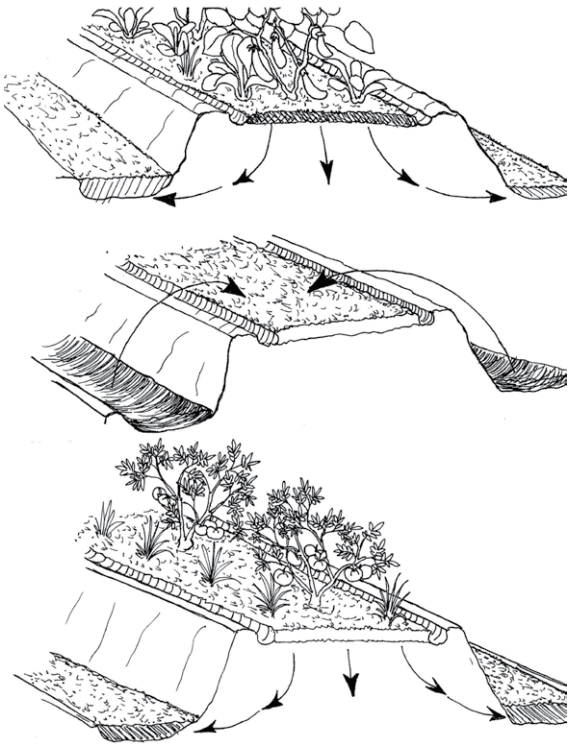


- Use finer (smaller sized) mulch for vegetable beds and coarser (larger sized) mulch for large crops and trees.
- For trees, underneath the outside leaves is the most important area to mulch. Continuous mulching improves tree health and productivity.

- For vegetables, plants and trees, DO NOT let the mulch touch the stems or trunks. This is very important in the wet season to prevent rot and mould.
- Use rocks, thick branches and whatever you can find to make garden borders. This helps to hold the mulch on the garden beds, give room for the soil to build up and prevent erosion.
- When you use weeds, separate seeding weeds and give these to animals or put them in liquid compost. This reduces future weed growth.
- Mulching the paths as well helps save water. Use green (fresh) mulch on the paths, and when it is brown (dry), you can put it onto the garden beds and add new green mulch to the paths. This method also helps to recycle nutrients because the green mulch absorbs nutrients and the brown mulch releases them.



Space between mulch and the stem



Mulching the paths

WET SEASON MULCHING

Be careful with mulching in the wet season because sometimes it can promote fungus, hold too much water in the soil and provide a home for wet season pests. This depends on your location (wet tropics and high altitude tropics are more susceptible), and what types of plants are growing (plants that like drier conditions are more susceptible). Observe what happens on your land and act accordingly.

Legumes

Legume are plants that PUT nitrogen into the soil.

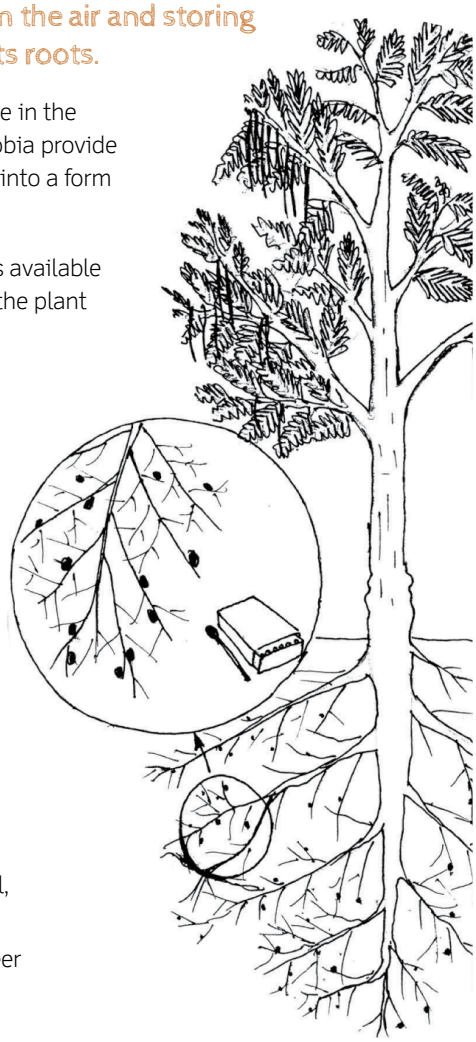
There are many different legumes in every tropical region, both annuals (plants that live for one growing season) and perennials (plants that live for three or more growing seasons). They are a very important part of any farm or system and can be used in many ways.

How do legumes work?

Legume plants work by "fixing" or taking nitrogen from the air and storing it in nodules (small storage balls) attached to the plants roots.

Bacteria called rhizobia form a relationship with the legumes and live in the root nodules, which are the size of match heads or smaller. The rhizobia provide nitrogen for the legume plant by changing the nitrogen from the air into a form the legume can use.

The nitrogen the legume plant does not use goes into the soil and is available for other plants. The rhizobia bacteria only move into the soil when the plant dies or when it drops roots.



Legume nodules

LEGUMES FOR TROPICAL CLIMATES

- **Annual legumes include:** All beans (including soybean), peas (including chickpea) and peanuts, clover, Crotalaria (rattlepod), Calopo (wild ground nut), Desmodium (tick-trefoil), Vigna spp (some examples include cowpea, adzuki bean, black lentil and green soy), Centrosema spp (butterfly peas)
- **Perennial legumes include:** Pigeon Pea (Cajanus cajan), Acacia spp, Leucaena spp, Albizia spp, Calliandra spp, Cassia spp, Sesbania spp, Gliricidia spp, Tamarind, Bauhinia spp, etc.

Always use local legumes in preference to imported legumes.

Legumes provide many other products and functions:

- **Products:** Food for humans and animals, mulch, compost material, timber, firewood, medicine
- **Functions:** Windbreaks, living fences, shade trees, trellising, pioneer plants, erosion control

Techniques for using annual legumes

Annual legumes can be grown with vegetables, annual crops and trees, and can be used as animal fodder.

To achieve the best results from annual legumes:

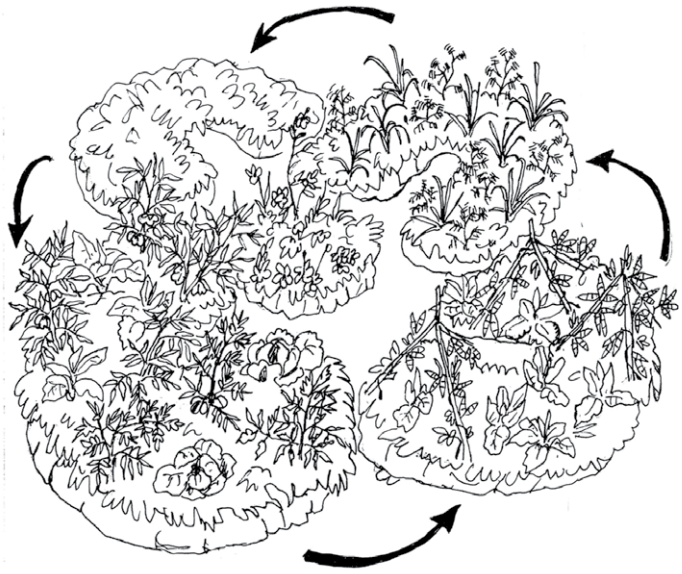
- Plants that are only grown for nitrogen fixing (not for food) should be cut back just after the first flowers. This is because the plants use a lot of the nitrogen during seed production, so not much nitrogen is left in the soil for other plants.
- Cut beans and peas off at the base or turn them into the soil when they are finished rather than removing the roots. This provides nitrogen for the next crop.

ROTATION OF CROPS

Different crops use different amounts of nutrients to grow. If you grow the same crop over and over again on the same plot, the soil nutrients become depleted and imbalanced.

For example:

- Pumpkins and melons love as many nutrients as they can get.
- Corn, potatoes and tomatoes use a lot of nitrogen and some other nutrients.
- Other vegetables like lettuce, cabbage and onions use nutrients but not as many.
- Beans and peas use nitrogen and other nutrients but also give nitrogen back to the soil.
- Carrots, beetroot and radishes like soil with fewer nutrients.



Rotation of crops

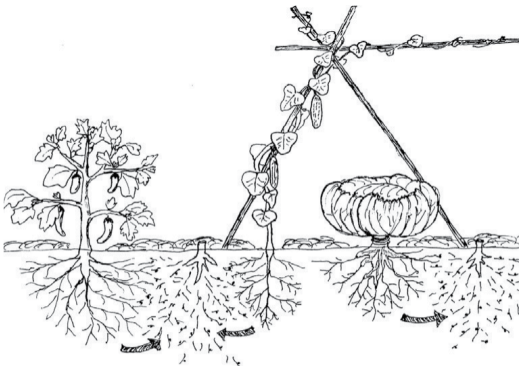
Therefore, it is good to rotate the crops from plot to plot each season or, even better, to grow different crops together. Legumes should be the main crop every third or fourth cycle, followed by a heavy feeder, such as corn or tomatoes. Crop rotation also helps to reduce pest and disease problems. It is important to include "rest time" in a crop rotation cycle. Rest time means that you grow nothing for a period, or instead plant a green manure crop. In this rest time, apply mulch, manure and compost either on top of the soil or turned into it.

You can also use animals in the rest time to add manure, improve the soil and reduce weed problems. Read Animals (**Ch 17**) for details about animals and crop rotation systems. Rest time allows the soil to recover and increases production rates for the rest of the year.

ANNUAL CROP INTEGRATION

Integrate legumes with other grain and vegetable crops at the same time. This technique increases the plot's diversity and yield. The other crops growing with them use the extra nitrogen that the beans and peas produce. You can even use perennials, such as Pigeon Pea, if they are regularly pruned. Farmers from many cultures grow beans, corn and pumpkins together and there are many other useful crop combinations.

Beans growing



Nitrogen released from bean roots for next crop

Integration can be mixed, in rows, in blocks, or in **whatever** pattern that suits the plants you grow and the shape of the plots and the land.

ANIMAL GRAZING AND LEGUMES

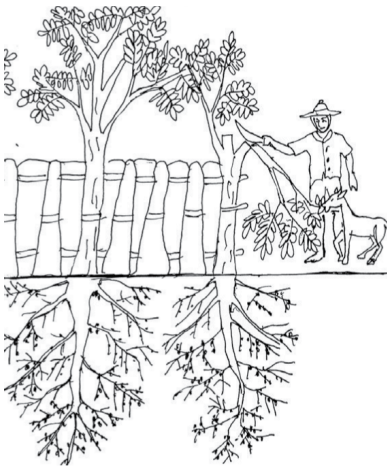
Add annual and perennial legume ground covers to grazing land for large animals. It improves the soil and provides additional food for the animals. See 'cow food' in Animals (**Ch 17**) for more information.

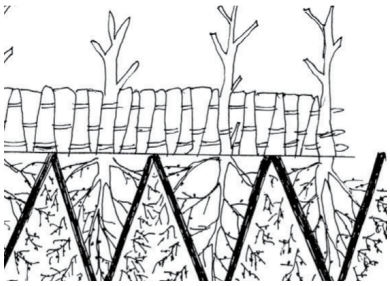
Techniques for using perennial legumes

Perennial legumes can be grown with annual crops, fruit and other trees, aquaculture plants, and as animal fodder.

To achieve the best results from perennial legumes:

- Prune them three or four times a year.
- When you prune a legume tree, the roots die back to an extent that corresponds to the amount of plant material you pruned off the tree. These dropped roots then release nitrogen into the soil for other plants to use.
- Use the plant material from pruning as mulch, animal food or in compost. As the legume trees grow back, the roots also grow again producing new nitrogen nodules in a continuous cycle.
- If a legume tree dies or is removed from the land, its old roots still provide nitrogen for a long time afterwards.

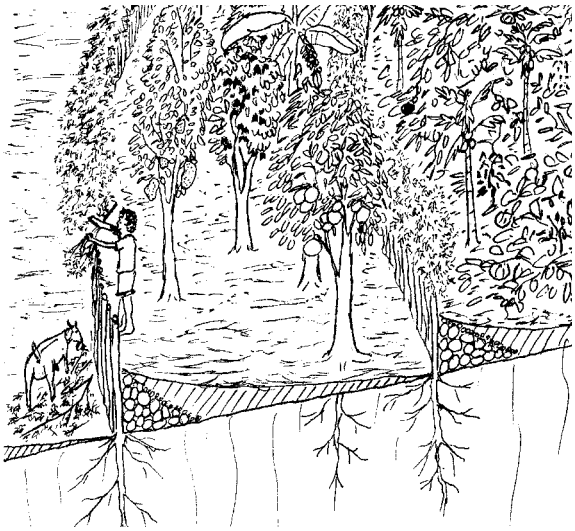


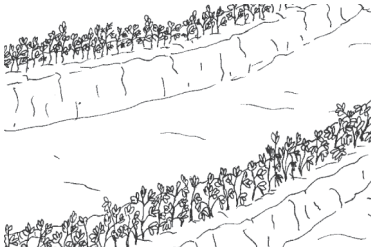


Roots die back

LIVING FENCES

Legume living fences are easy to grow from seeds or cuttings. If you continuously prune the fences, they turn into a thick hedge. The fences can also be windbreaks for vegetable plots, chicken and animal systems, aquaculture and nurseries. Importantly they are fast growing. The plant material from pruning makes excellent animal food, mulch or compost material. Near the house and for vegetable plots, the legume fences also protect the crops from animals, and on sloping land they stop erosion.





Tree terrace just planted

LEGUME TREE TERRACES

Legume trees can create living terraces as follows:

1. Plant the seeds on contour with the land.
2. Plant them very close together, 10 cm width apart.
3. Combine legume trees with small swales to improve results. The following chapters have many examples of using swales and explain how to make them: Permaculture design strategies and techniques (**Ch 3**), Family gardens (**Ch 10**), Sustainable agriculture (**Ch 13**) and Trees (**Ch 15**).

TERRACE AND RICE PADDY EDGES

Legume trees can be planted along the edges of terraces and rice paddies. For terraces, use only legumes that can be continuously pruned with root systems that do not damage the edges. And for rice paddies, use legumes that like clay soil and a lot of water.

PERENNIAL CROP INTEGRATION

Integrate legume trees with fruit and nut trees, coffee plants, and vegetable and grain crops. The legume trees provide nitrogen, mulch, and protection from wind and erosion. They can be integrated in rows, blocks, mixed or a combination.

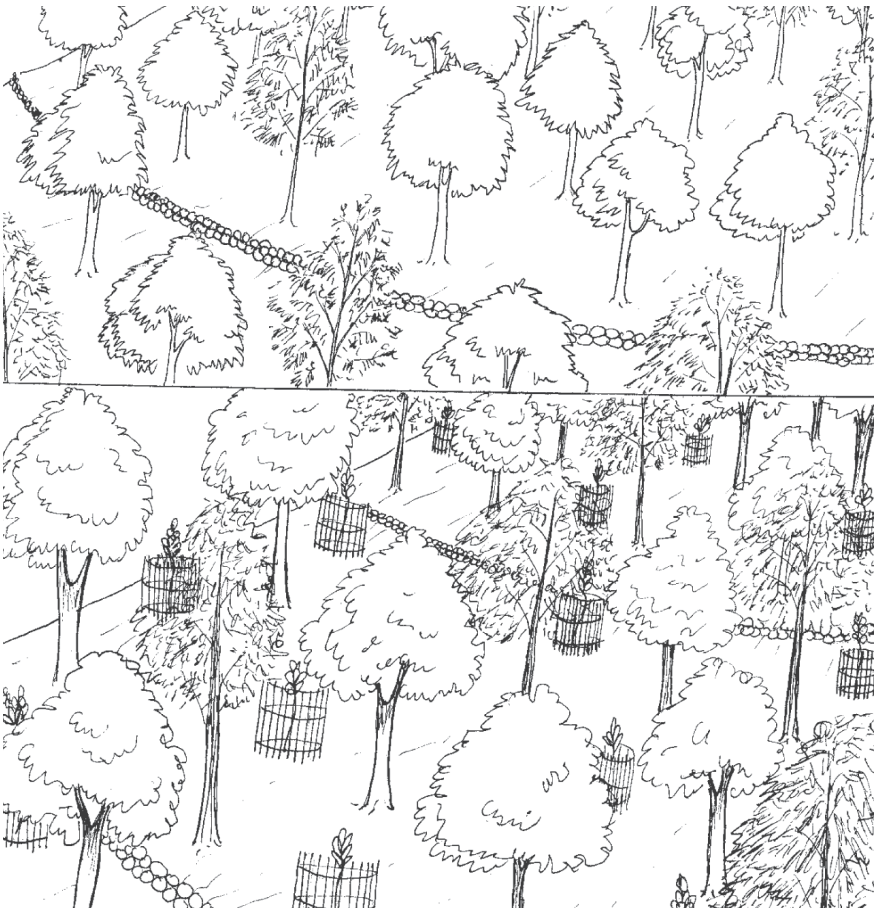
Taller legumes, such as Albizias and Sesbanias, provide shade for coffee plants, vanilla and other shade friendly crops. Animals need some shade as well, and legume trees can quickly provide this function.

PIONEERS

Pioneers are trees that are planted first in a system and act as protectors for the newer trees. Pioneer trees can be used in reforestation and in any tree system to reduce wind, stop erosion, improve the soil and provide mulch. As pioneers often grow in hard conditions, pick trees that do not need much water and can best withstand hard conditions. Pioneers make the conditions better for future trees.

Legumes make the best pioneers because they:

- Are easy to grow from seeds or cuttings
- Grow quickly
- Provide nitrogen for other trees



SMART IDEAS:

- Legumes are mostly short-lived trees. Use the trees with short lives for pioneers (e.g. Acacia, Pigeon Pea, though the longer-lived Albizia and Leucaena make good pioneers too), and legumes with longer lives for living terraces, windbreaks, shade and living fences (e.g. the Leucaena, Albizia, Sesbania, Casuarina, Acacia and Gliricidia)
- Plant many more legume pioneer trees than you need. After the first and second years, cut out the weaker, smaller trees to provide mulch and give room as the productive trees grow. This also provides a guide: weaker, smaller trees show where the soil and growing conditions are not as good therefore, do not to plant fruit trees in those areas.
- If you plant legumes on sloped land, when nitrogen is released it slowly filters down the hill in the soil. This feeds plants below the legumes.
- Remember that legumes are multifunctional. They provide in MANY different ways, so make use of as many of these benefits as possible.

Green manure crops

When not using land for growing rice, corn or other vegetable crops, you can improve and better prepare the soil for the next crop by planting a "green manure crop" of annual legumes and/or fast growing annual plants. The green manure crop should be planted thickly and cover the whole area. Use a mix of legumes, annual grass and other annual plants. They can be used for small family gardens through to large agriculture systems.

Grow the green manure crop as food for the soil, but it can be food for animals and humans too.

For maximum nitrogen yield — just after the first flowers appear the crop can be turned into the soil, cut back and left as mulch or animals can eat the crop. This method puts back more nutrients, including nitrogen, into the soil and provides lots of organic matter.

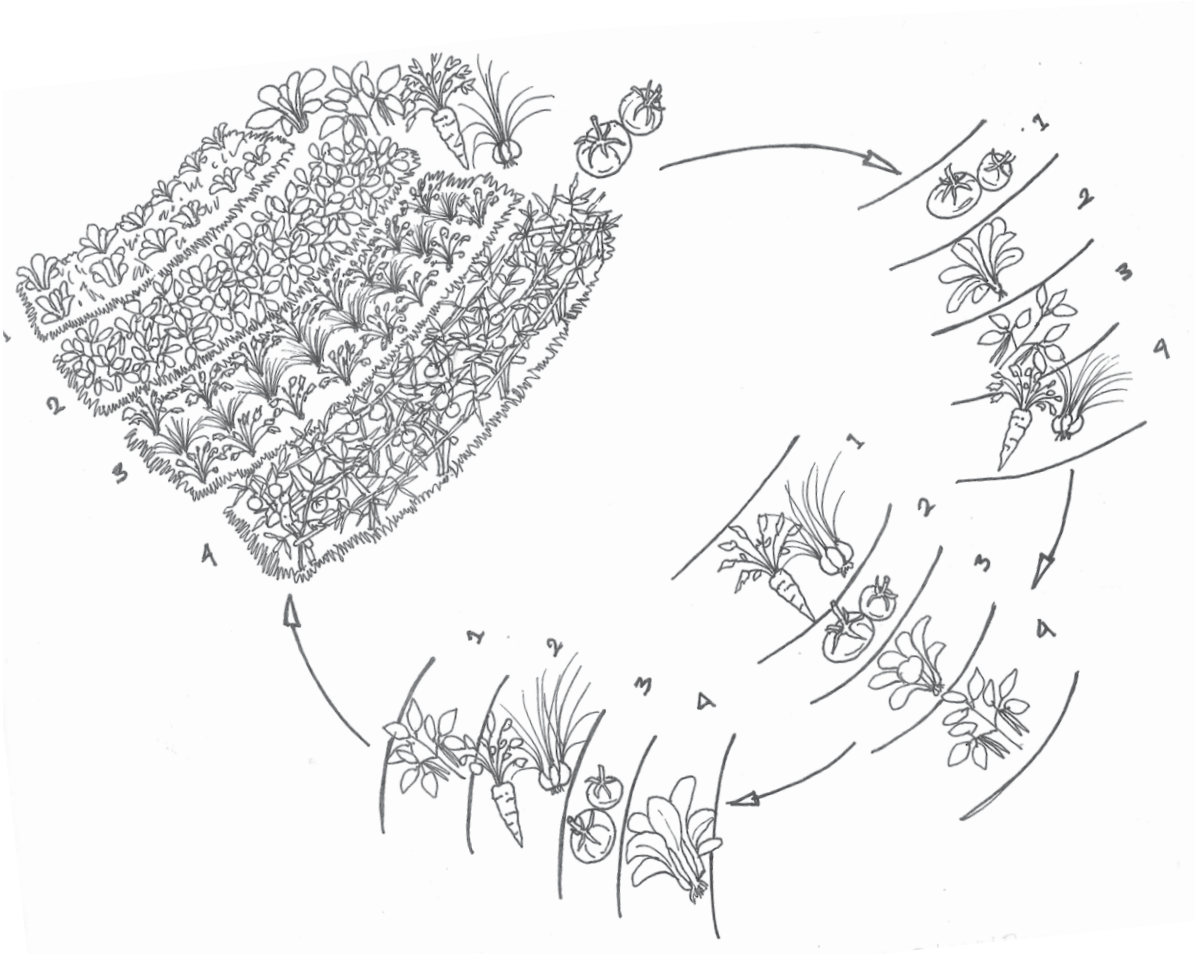
Green manure crop in rice paddies

For food harvest — after harvesting, the crop can be cut back and left as mulch, or animals can eat the remains. This method produces food, great mulch and good organic matter, but slightly lower nitrogen and nutrients overall.

Green manure crops take time and labour, and may require a little bit of money, but there are many benefits:

- A lot of nitrogen from the legumes' root nodules is left in the soil for the next crops.
- Many other nutrients are returned to the soil from the plants for the next crops.
- A lot of organic matter, humus and mulch from the green manure crop have been produced.
- Soil biota and good fungus in the soil increase a lot.
- Soil water retention and aeration improve.
- Erosion and weed problems reduce.
- They can reduce or control some soil diseases.

These benefits all help to improve the soil and soil structure and increase yields for the next crop. Thus the increase in production more than pays back your work and the time spent on the green manure crop. Remember to let about 10%–20% of the crop go to seed. This should be collected and stored for next year's crop.



Crop rotations including a green manure crop

SMART IDEAS:

- Green manure crops can be used on land that has not grown grains or vegetables before. This technique helps to prepare the soil for future production.
- Be very careful not to introduce green manure crops that could become problem weeds in the future.

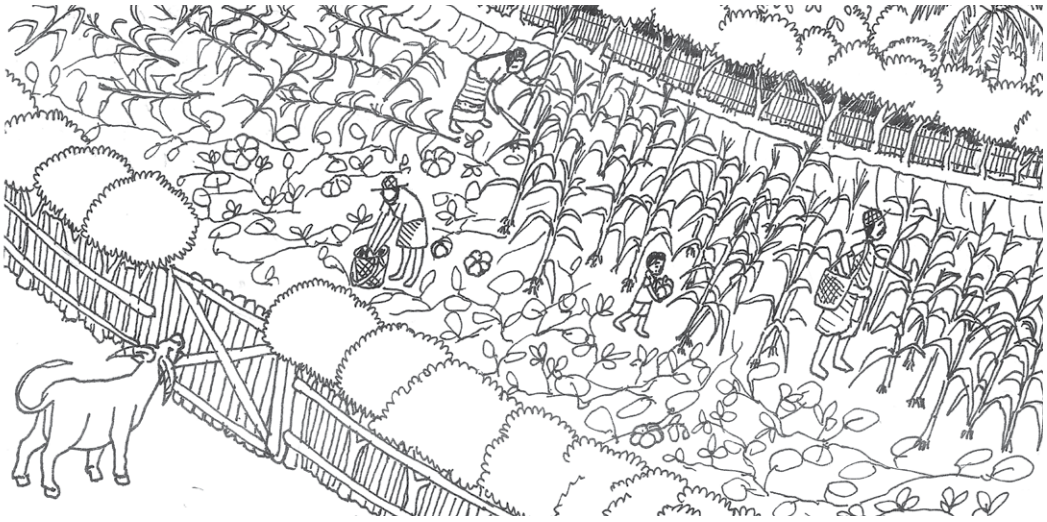
Crop waste and weeds as soil improvers

CROP WASTE

When you harvest your crop you are left with the waste; the stalk, some leaves and the roots. The worst thing you can do for your soil and the environment is to burn it!

The best things you can do are to dig it back into the ground or simply chop the stalks, let the roots decompose and use the stalks as mulch. To help with this process add micro-organism activators.

Other good options are to let animals onto the crop land to eat the stalks and leaves, and use their manure, or collect the stalks and leaves to use in composts.



Leaving the crop waste for mulch or animal food

WEEDS

Sometimes plants that are common weeds can be used for improving the soil. This turns them into a resource, and by harvesting them you also control them. A successful trial in Timor-Leste by World Vision staff was with Mexican Sunflower - Tithonia diversifolia. It is a very common weed in many areas and is considered a big problem, but it is an excellent resource to improve the soil. The plants are cut back regularly and used for:

- Biomass and turning it into the soil
- Mulch
- Making compost
- Loosening the soil through their large root systems
- Green manure crops - chop them back as they start to flower, the same as for other green manure crops, and do not let them seed.

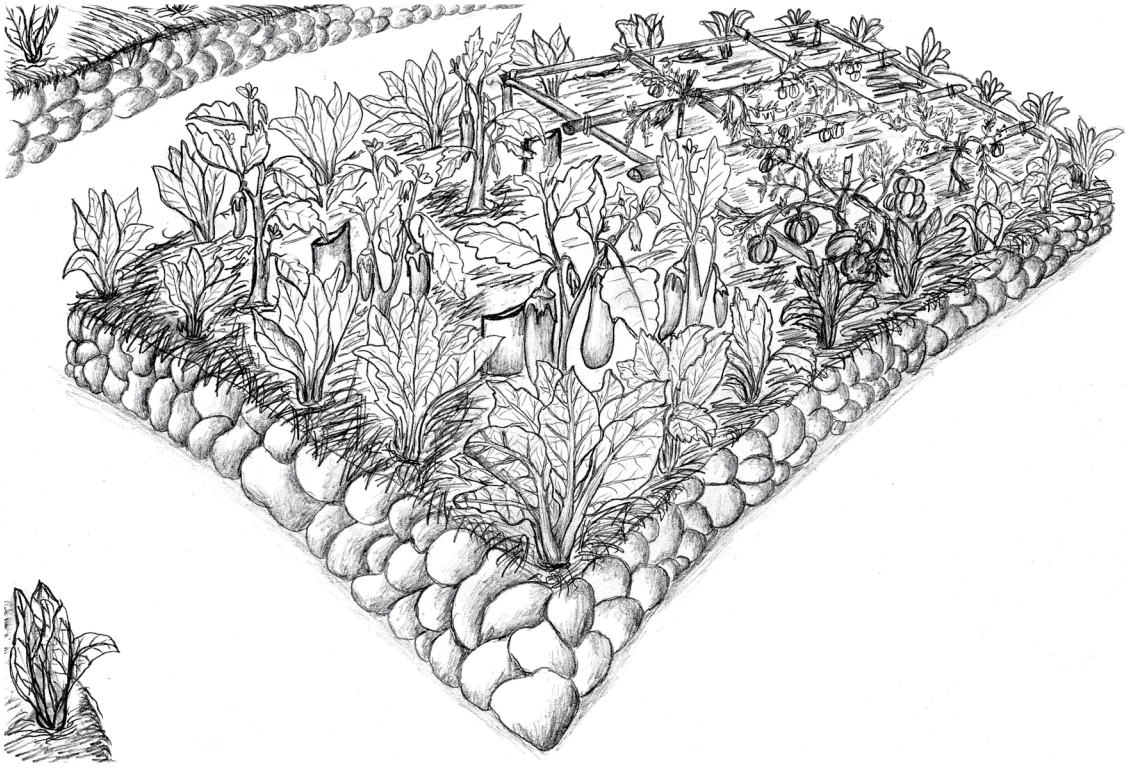
By using weeds in this way it puts nutrients back into the soil, reduces weed seed production and helps to stop them spreading. Other common weeds that could be used are cowpea, calopo, and water weeds, such as water hyacinth and water lettuce. Weeds that produce lots of leaves and/or have a deep tap root are good. Do not use weeds that spread by bulb or underground runners.

Living soils

To end this chapter we return to the most important idea. Healthy living soil is the base for productive and sustainable agriculture. This is true in small home gardens and large grain crops, rice paddies, tree crops, bamboo and when raising animals.

If the soil is well managed in a healthy farm system, it will become more fertile over time and continually produce healthy crops. When you grow, collect and make the resources for building and maintaining the soil, you are making the most of what you have, creating a low cost continually improving garden or farm. That is what healthy living soil provides and what chemical based systems cannot.

Living soil leads to healthy nutritious plants that improve the health of people and animals.



SOILS
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A family garden provides many benefits for many people and is at the heart of family life. A healthy and productive family garden provides:

- Tasty and nutritious non-staple foods all year round
- Extra food to make sauces, pickles, jams, etc
- Medicines, cooking herbs, and spices
- Income from the sale of surplus family garden produce
- Vegetable seedlings, as well as fruit trees, native trees, and other crops when the garden includes a small nursery

This chapter explains:

- Garden site analysis
- Integrated garden designs
- Garden bed designs, including 'gardens with compost' techniques
- Reducing garden maintenance
- Planting times and methods
- Integrating animals, paddies, and fish ponds with your garden
- Later in the guidebook (**Ch 17** Animals and **Ch 18** Aquaculture) there are many more techniques for integrating small animals with garden systems.

The results are a highly productive garden, providing year-round food and income, which is low maintenance, using local, cheap, and organic garden resources. The farmers, not businesses, control the management and resources. Resilience and sustainability are high and improve each year, especially when also using other techniques, such as seed saving and food preserving.

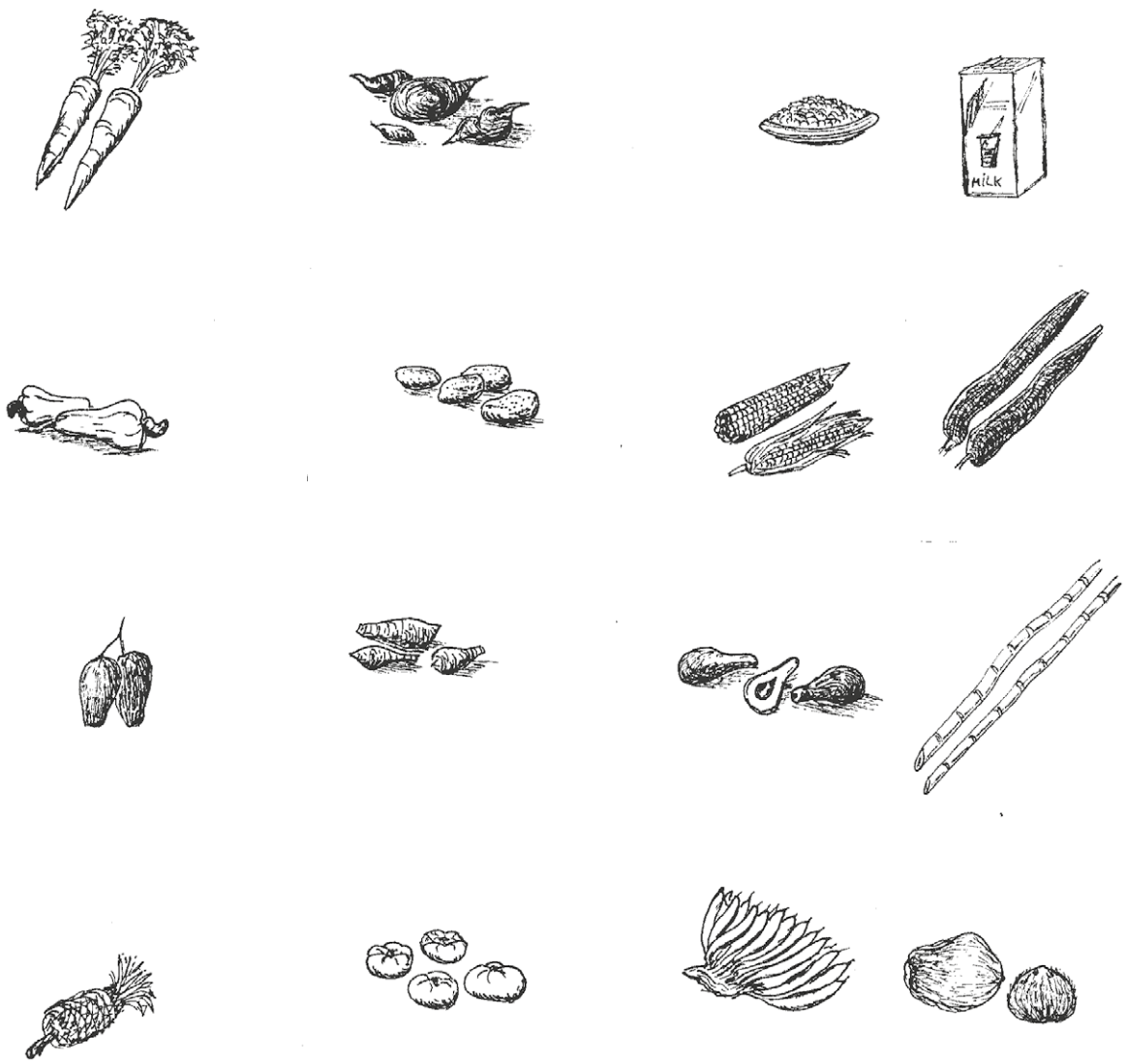
Use this chapter as a checklist for your family garden, whether you are creating a new garden or improving an existing garden. The design techniques are the same for both.

STEP BY STEP GARDEN SITE ANALYSIS

A site analysis helps you to make a good garden design that leads to a productive, efficient garden. A little planning now saves a lot of time and energy later.

A site analysis is important for new and established gardens. It observes, considers and records all of the natural and non-natural factors at your garden site. Think about the positive and negative impacts on your production from each factor: design your garden to gain maximum benefits from these factors, while preventing any negative impacts.

There is a lot of local knowledge about tropical agriculture, and it is growing all the time. Improving food production relies on this knowledge being shared. This chapter uses a lot of these ideas and adds techniques that use local materials and suit local needs. Integrate this with your local knowledge.



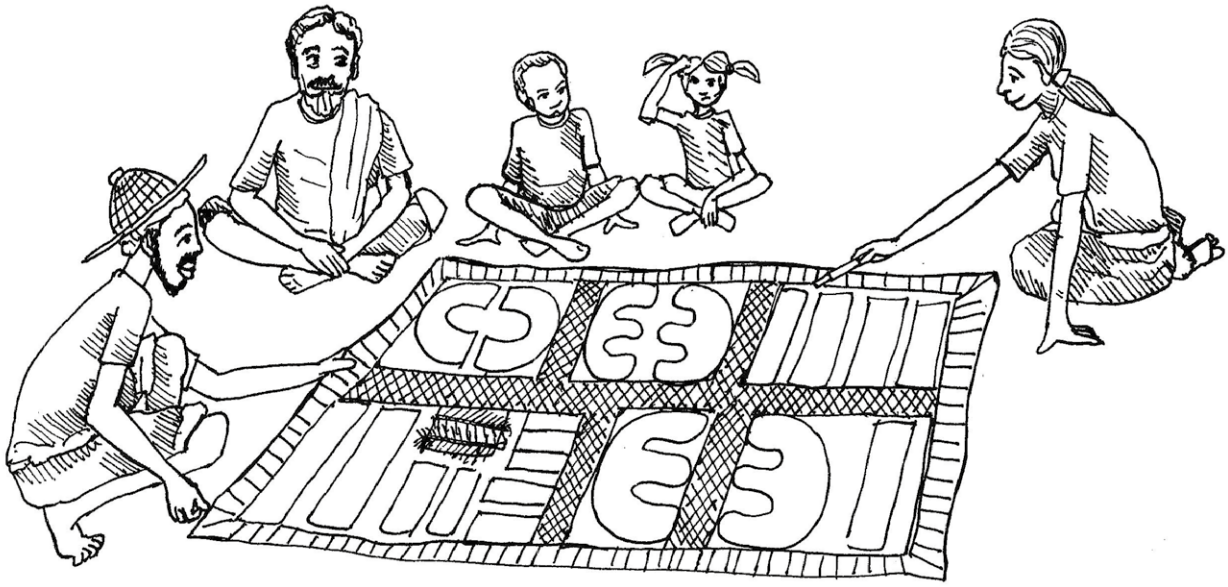
GARDEN LOCATION AND ACCESS

Most tropical family gardens are far from the house. Sometimes these are big gardens, sometimes small. In this guidebook we call the big gardens 'sustainable agriculture' (Ch 13) and the small gardens 'family gardens'.

Most techniques are very similar for both. Gardens around the house often just have beautiful rather than productive plants. However, gardens can be beautiful and provide food, spices, and medicine. We recommend having a small family garden close to the house to provide for daily cooking and good nutrition. Read in Food, health, and nutrition (**Ch 8**) about important plants to have around the house: most of these plants are beautiful and functional. Remember that flowers provide important functions in all gardens, not just those around the house.

The information in this chapter can be used for ALL family gardens.

It is recommended that family gardens are close to the house, and close to a water supply. Access to the garden is vital to bring in resources and take out produce. The location is usually fixed, so access might need improving to help with transporting produce and bringing in garden resources.



Mapping access points and paths

Family gardens are generally considered Zone 1 in your permaculture design, sometimes with elements of Zone 2. A family garden is intensive, visited daily, and highly productive. Sometimes they include small nurseries, small animals, and some food for markets where the land is big enough and water supply is adequate. Primarily, they are for producing highly nutritious food for families.

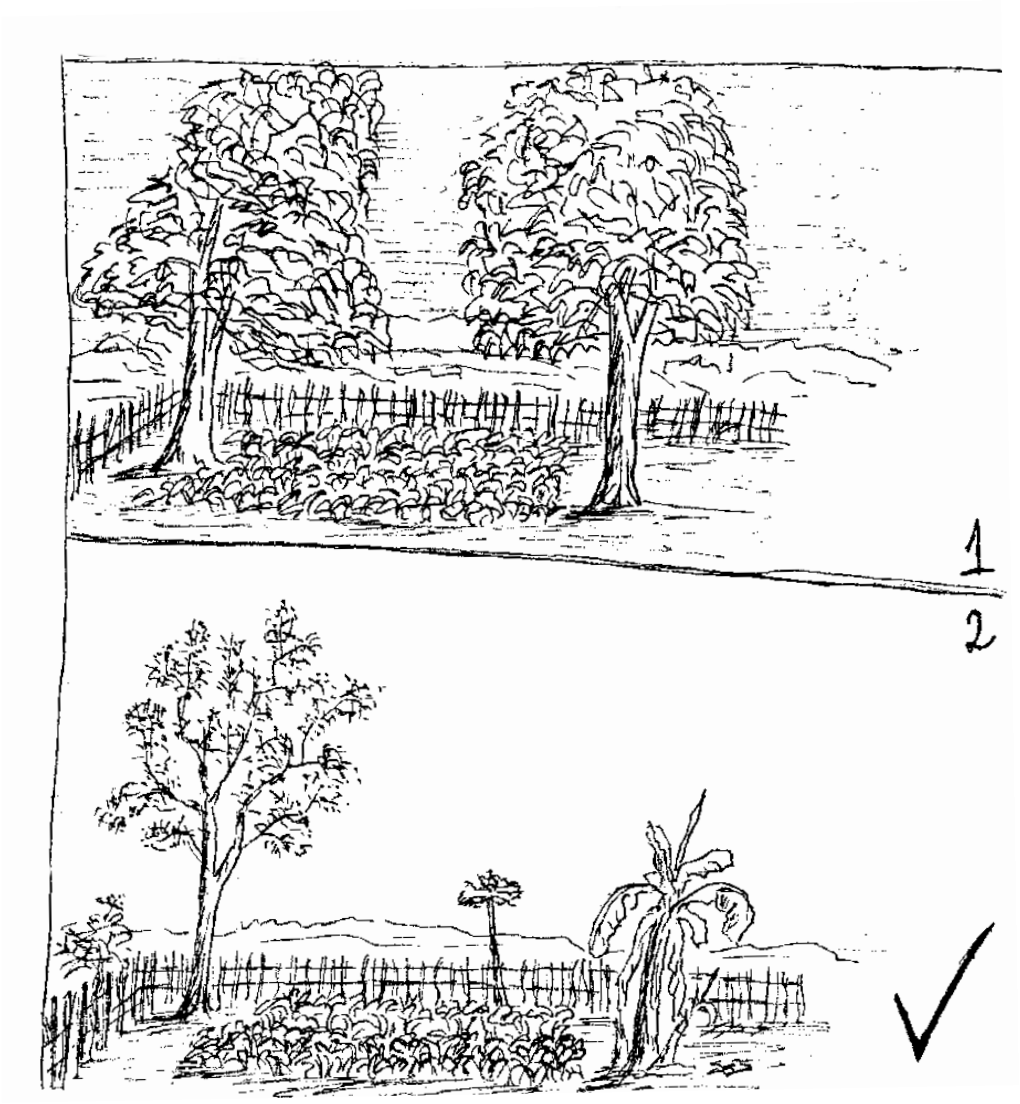
SUNLIGHT

Plants need sunlight to grow well and produce large crops. They absorb sunlight and change it through the process of photosynthesis into plant food. Some plants produce well in some shade, but most plants prefer full sun.

Vegetables that grow well in some shade are amaranth, beans, cabbages, cucumbers, lettuces, peas, potatoes, pumpkins, and green-leaf vegetables. Experiment for yourself. Some shade means not more than a third of the day in shade OR thin-leaf trees providing half a day's shade.

Do not plant tall growing trees near vegetable beds, especially trees with thick leaves. You can grow small trees, such as bananas, pigeon peas and papayas, and trees that are regularly pruned, especially legume trees. Be careful not to plant too many and use them wisely.

The sun damages plants at the hottest time of year before the wet season starts. Look at where you can create shade during the middle of the day for these months to reduce stress on the plants and help them survive.



1. Too much shade
2. Right amount of sun

WATER SUPPLY

In many areas water has to be collected far from the house and garden. A water supply is one of the most important factors to increase garden production.

Collecting rainwater for irrigation and using the overflow water too

In the dry season access to water is needed to grow vegetables and is necessary even in the wet season in many areas. Cassava, bananas and some other crops can survive through the dry season with no water, but they produce very little.

Therefore, the garden must be close to a water supply OR you will need to bring the water to the garden.

Bring irrigation water to the garden in pipes made from bamboo, metal or plastic hose, or dig water channels for the water to run along.

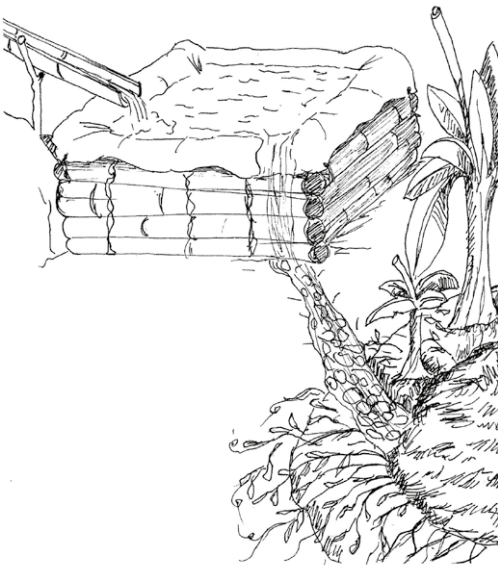
Store rain or irrigated water near the garden in water tanks or drums to provide a continuous water supply.

Another way is to dig small or large holes and line them with concrete, clay or thick and strong plastic sheet for catching rain or irrigated water. These will hold water for gardens and for animals. Make simple tanks using bamboo for frames and line them with thick, strong plastic sheets or tarpaulins. 2 x 2 metres wide and 1 metre high is easy, but make the size to suit your needs.

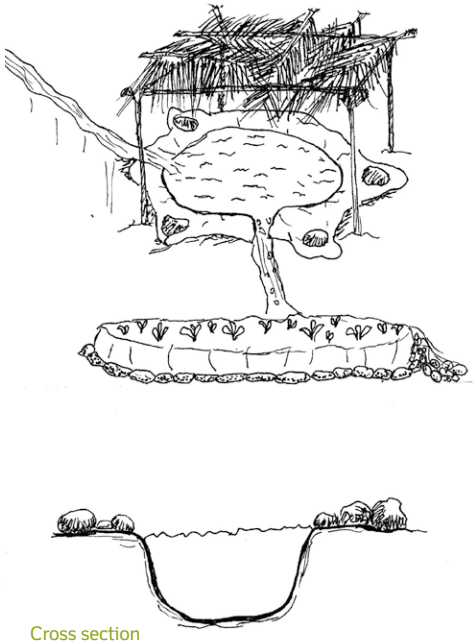
This amount of water might not seem like much but it helps a lot to make sure wet season plants have water during dry periods and to extend the wet season water supply. They can also hold irrigation water in the dry season if it is available.

Use different techniques to prevent mosquitoes:

- Add a few mosquito larvae eating fish (best option) to the water.
- Cover the top of the water with woven mats, shade cloth or mosquito netting.
- Place a cup of neem fruit/seeds and four cups of neem leaves in a cloth with a rock, tie it up and sink it so neem oil slowly releases into the water. Replace the neem every three months.



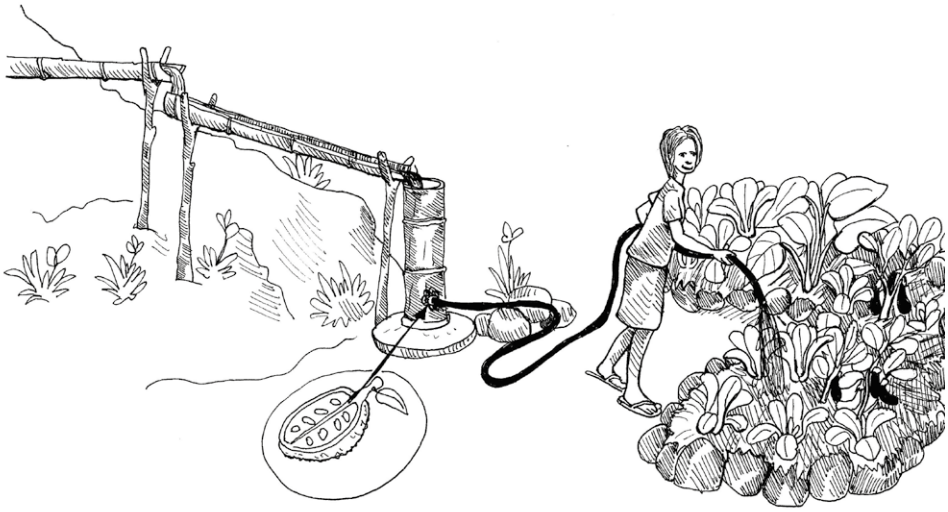
Methods for catching and storing water for irrigation



Cross section

SMART IDEA:

On sloping land, split bamboo can carry water from a spring, or from bamboo pipes that are already running water to farms, into a wide piece of upright bamboo with nodes knocked out leaving only the bottom node. Secure the upright bamboo to a stake in the ground at the top of the garden. Cut out a hole near the bottom, put in a hose and seal it with jackfruit sap or tree gum. There will be enough pressure to water the garden with the hose. When you have finished watering simply stop the water at the start of the split bamboo.



You can also collect water from your house roof or any building large or small, especially those that have a metal sheet roof. You can either buy or make a gutter out of bamboo. Store the water in a tank/s. This water is NOT recommended for drinking as some metal sheets can release lead and other metals into the water, contaminating it.

Your stored water must be covered to reduce mosquito breeding and to decrease water loss by evaporation. Use the neem recipe described on the previous page, once every three months, to help prevent mosquitoes, but do not put it in the drinking water tanks.

Use gravity (water running down hill) wherever possible to collect and create your water supply and irrigate your land. It is easy and cheap. You can also use gravity to run water from storage tanks. If you place the garden below the water supply, it makes watering easier. Hand pumps and foot pumps also help bring water up from underground. Read in Houses, water, and energy (**Ch 7**) about pumps.

Protecting and using natural springs

Develop all irrigation in cooperation with other water users!! If you form a community group, tanks, pipes, and water pumps are cheaper to buy and easier to make and maintain. The extra water can then be shared, and everyone in the group benefits.

Techniques for reducing water use, extending wet season growing time, and getting maximum benefit from the water are explained later in the chapter.

SOIL

Find a balance between an area with good quality soil, and closeness to the house and water supply.

Rich soil will produce more vegetables and need less water, and most soils can be improved quickly with continuous mulch and compost. Heavy clay and waterlogged soils need specific techniques and time to make them productive. It may be more valuable to use these soils for something else, such as for fish and water plants. Water is a more important factor to consider than soil quality when locating a garden.

Improving soil for good food production

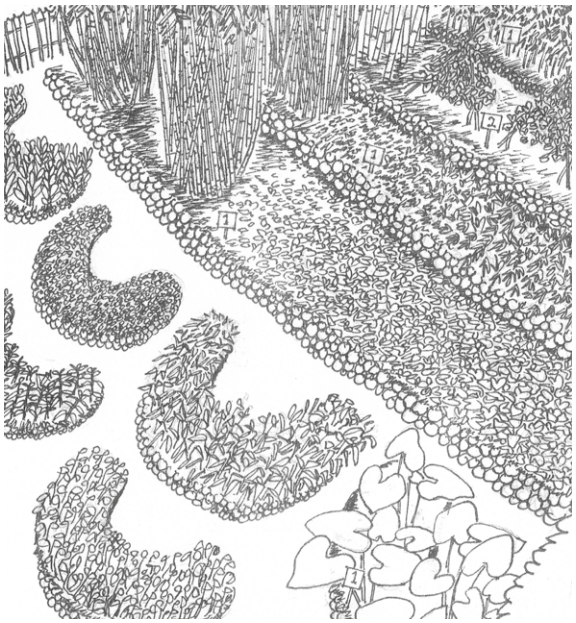
LAND CHARACTERISTICS

The characteristics of your land determine what type of garden beds you create and what you can grow.

For every type of land, your goal is to retain and improve your soil over time.

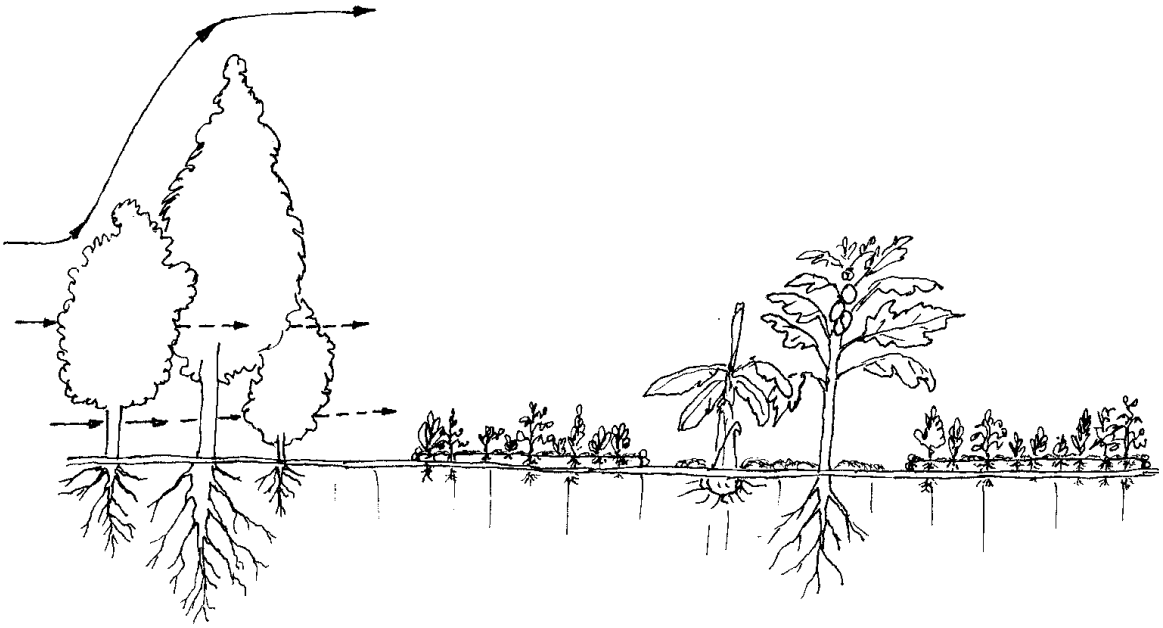
Some examples:

- Flat land — raised garden beds
- Gently sloping land — terraces and/or swales with some raised beds
- Steeply sloping land — terraces and/or swales using tree legumes to help secure the soil
- Swamp land and flood-prone land — raised garden beds with good water drainage, trenches, and fish ponds/small paddies

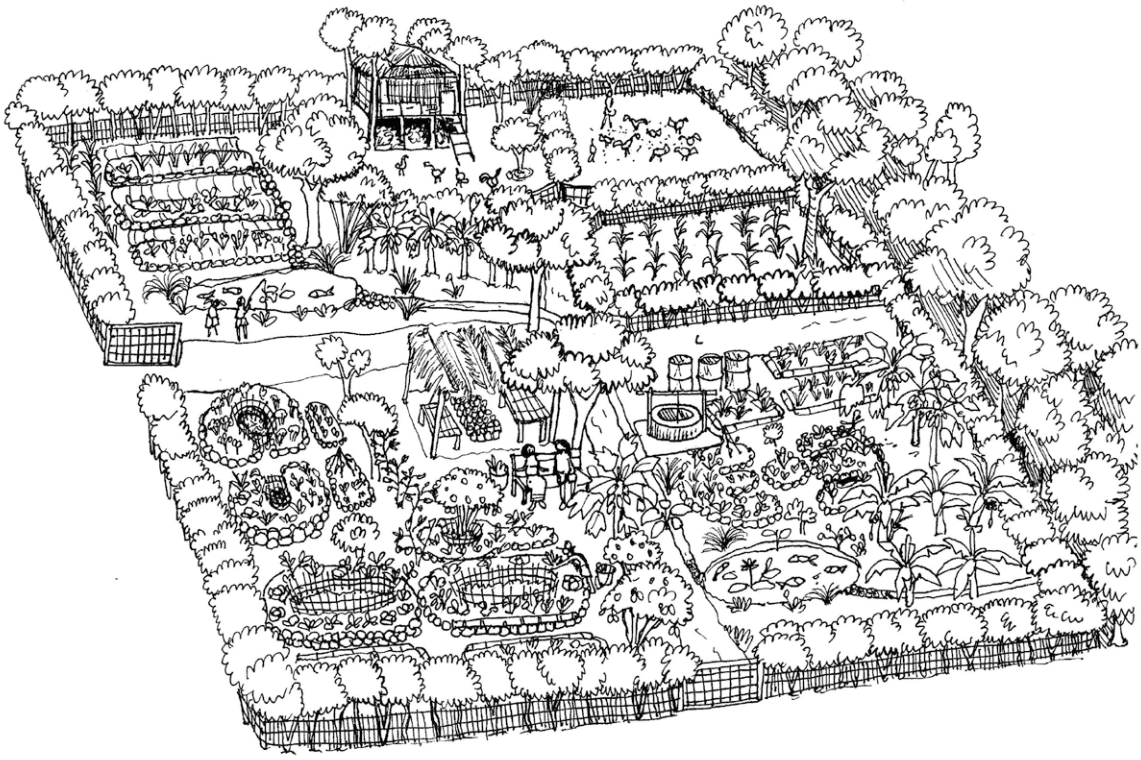


WIND

Vegetables, especially seedlings, need to be protected from strong winds that dry the soil and take moisture from the plants. Windbreaks and living fences reduce water needs for your garden, and the protected plants grow much faster.



If the garden is close to the house, the windbreak for both house and garden can be combined. Windbreaks also provide compost material, animal food, a habitat for pest predators, food, medicine, and much more.

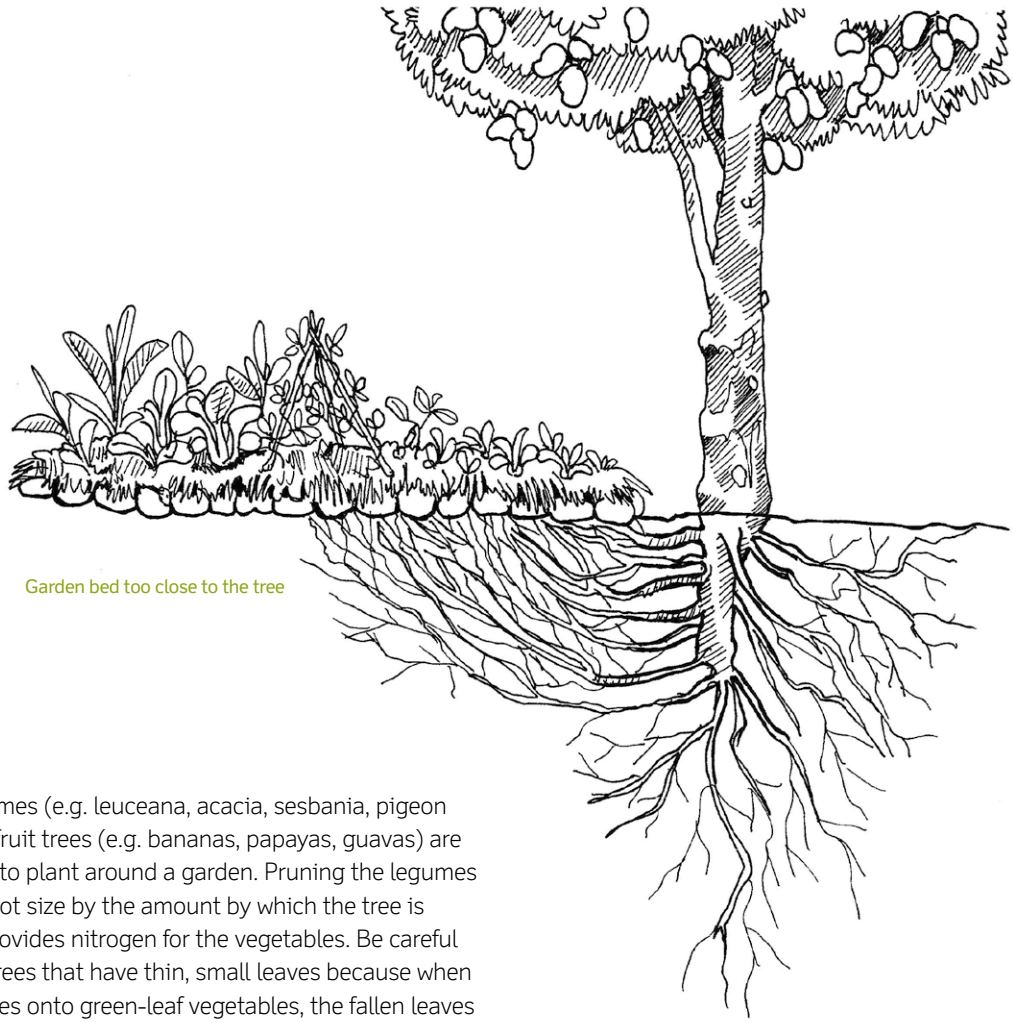


Windbreak on the right protects the garden

TREE COMPETITION

Large trees have roots that spread out in the ground to two-thirds of their height and the same width as the trees.

Tree roots compete with vegetable crops for water and nutrients. Some trees compete more than others. Trees with large and hungry root systems should not be planted near intensive vegetable and fruit tree areas. Generally it is better to separate trees from vegetable gardens, especially for root crops.



Thin-leaf legumes (e.g. leuceana, acacia, sesbania, pigeon pea) or small fruit trees (e.g. bananas, papayas, guavas) are the best trees to plant around a garden. Pruning the legumes reduces the root size by the amount by which the tree is pruned and provides nitrogen for the vegetables. Be careful with legume trees that have thin, small leaves because when they drop leaves onto green-leaf vegetables, the fallen leaves can create rot problems, especially in the wet season.

CLOSENESS TO HOUSE

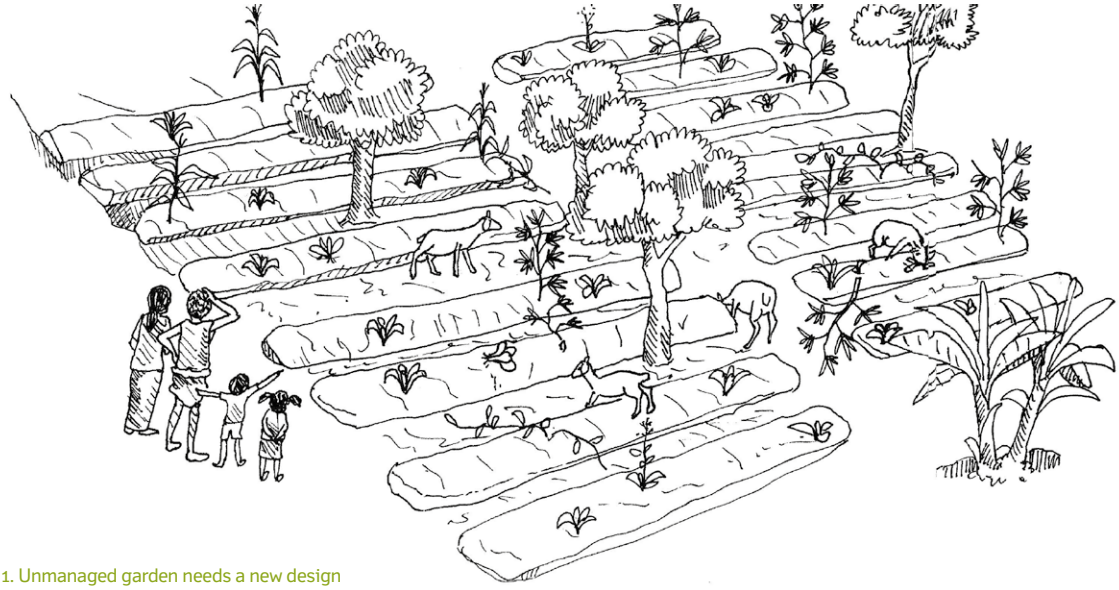
The closer your vegetable production is to your house, the less time you need to care for it, and the more energy you save.

Transporting resources and produce is easier and faster. Sometimes the main family garden has to be further away from the house so that it is close to a water supply. In this case you can still have a small garden, such as an African keyhole garden or compost trench garden, next to the house because it can reuse the house's waste water. See later in the chapter for how to make them.

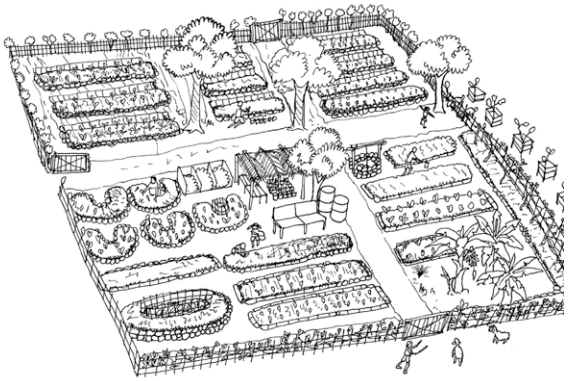
This factor must be balanced with the other factors.

INTEGRATED GARDEN DESIGN

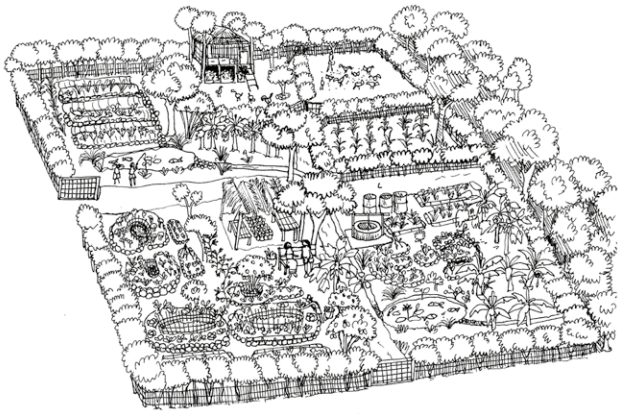
Your garden can be newly created or an existing garden redesigned and improved by using the site analysis and integrated garden design ideas. When deciding where to put your garden you must balance sunlight, water supply, soil, land characteristics, and closeness to the house.



1. Unmanaged garden needs a new design



2. New garden design after 1 - 2 years



3. New design with integrated animal systems after 5 years

The garden is designed around:

1. Water flow and water management, especially in the wet season
2. Access to your garden via pathways
3. Shape and size of your garden beds to suit the land characteristics
4. Placement of ponds, compost and garden resource areas, small nurseries, fences, trees, and other garden features

You will gain many benefits from designing an integrated garden:

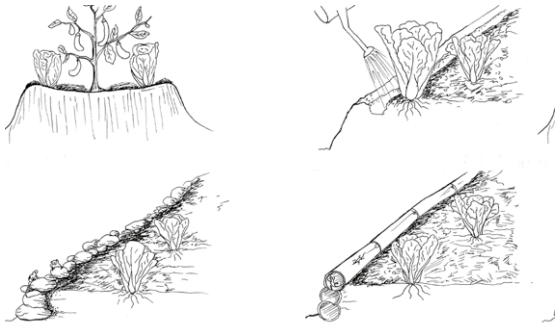
- Less and easier maintenance
- Improved quantity and nutritional value of the food produced
- Reduced inputs and costs
- Greater resilience: reducing susceptibility to adverse financial and climatic events
- Fewer pest attacks
- Reduced risk of total crop failure
- Easier crop rotation to limit the build-up of weeds, pests, and diseases
- Including legumes to increase the availability of nitrogen for the crops
- Enables the integration of multi-purpose plants that provide farmers with a range of useful products
- Stops destructive slash and burn (shifting) agriculture

WATER FLOW AND WATER MANAGEMENT

Dry season: design your garden so that it is easy to water and the water is used efficiently.

Good pathways and raised beds will fulfill these needs. Borders (e.g. stones, branches) or indented edges for the beds make them even better. If you have irrigation, make sure you design the shape of the beds and the paths to suit your irrigation system. This can include using paths for flood irrigation.

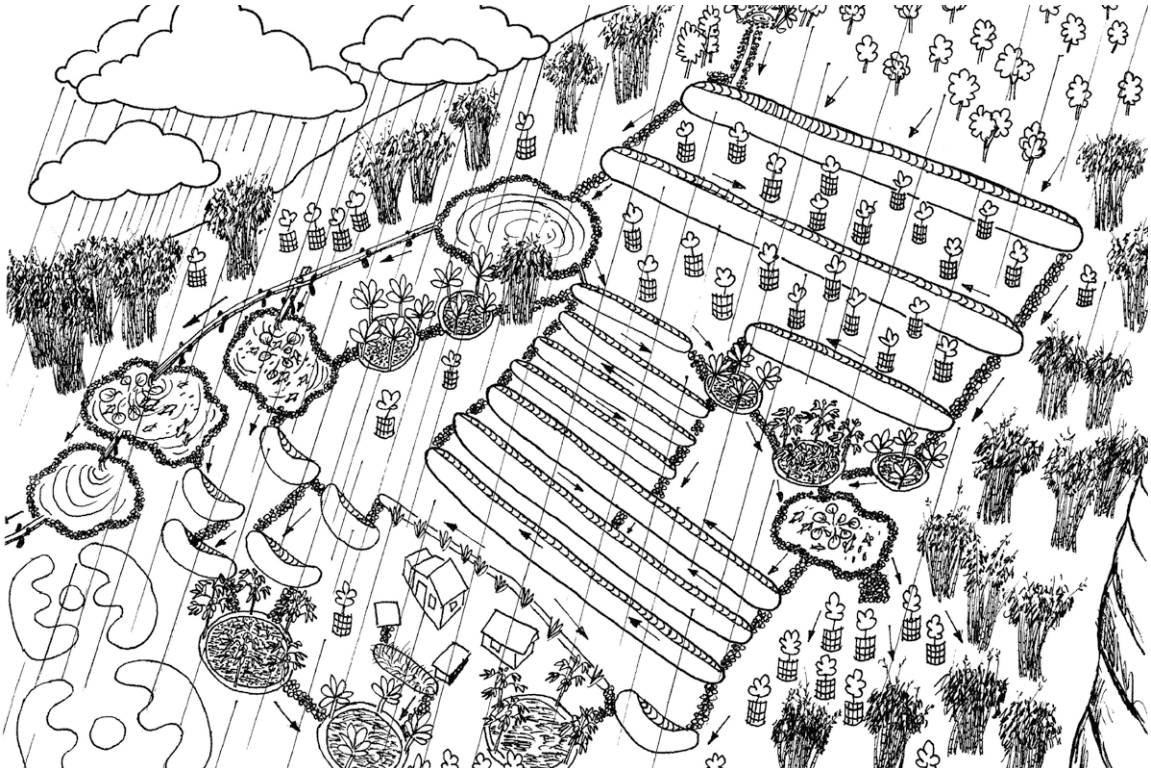
Many communities plant in sunken garden beds in the dry season, or in the trenches of swales. The swale trenches can be divided into smaller beds. This saves water and makes water management easier and more efficient.



Different garden bed techniques for holding water

Sunken garden bed in a swale trench for the dry season

Cross section of sunken garden bed



Wet season: design your garden to catch and store rain water in the garden beds, swale trenches, banana pits, and ponds.

Your design MUST also allow heavy rains to flow gently out of your garden via paths and overflow trenches. The water will move even on flat land. A good design moves the water, stores it in ponds and earth, and allows the excess water to keep moving.

Overall you can catch and store 50% to 75% or more of your wet season rains by:

- Directing where the rain water moves to
- Catching and storing as much rain water as possible in the ground as it moves through your garden
- Releasing excess water from heavy rains and extreme weather events

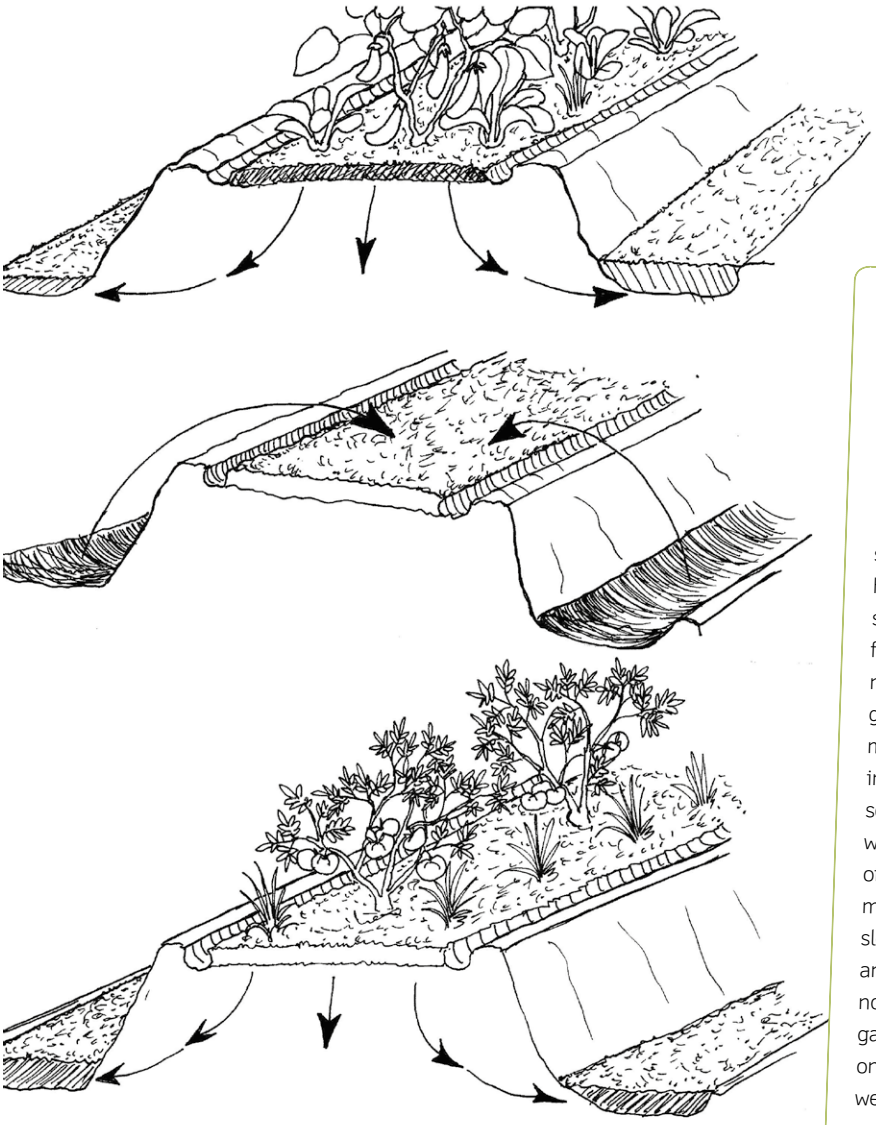
This design strategy is becoming more and more important due to climate change and less reliable rainfall.

GARDEN ACCESS AND PATHS

Design your main paths wide enough for cart or wheelbarrow access on main paths, and room for walking on side paths. This is vital so that you can easily water, spread compost and mulch, as well as harvest and clear after harvesting.

Your paths also provide other important functions:

- They allow wet season heavy rains to drain away and not damage your garden beds, even on flat land.
- They redirect water to garden beds in the dry season.
- They are an excellent barrier for stopping some weeds from entering your garden.



Cycling path materials onto garden beds

Remember that pathways make the garden beds much easier to maintain and more productive.

SMART IDEA:

Your paths can catch nutrients and return them to your raised garden beds! Cover your paths with fresh (not dried or aged) mulch, such as rice husks, coffee husks, coconut husks, sawdust, bamboo leaves, fresh grass, and even old newspapers. This slows weed growth. In the dry season the mulch helps keep moisture in the soil. In the wet and dry seasons the mulch soaks up water and nutrients that run off the garden beds. Fresh mulch absorbs nitrogen as it slowly dries and decomposes, and this is why you should not put it directly on your garden beds. If you put it on your paths, it works very well and after six months you can take the mulch from the paths and put it on your garden beds. Then add more fresh mulch on the paths, and start the cycle again.

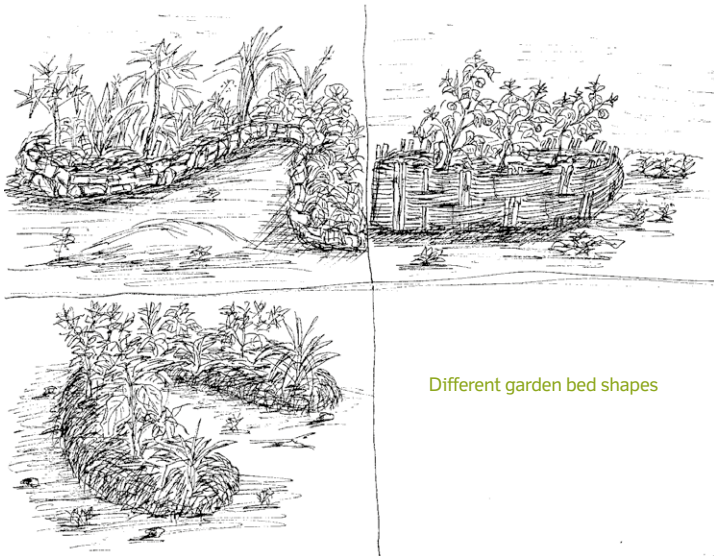
GARDEN BEDS

Once you have designed the land for water and access, you can design your garden beds. The shape of the garden beds varies according to the shape and slope of the land. Work with the land, not against it. You do not have to make garden beds in straight lines. Be creative: remember that beauty and natural patterns are also important.

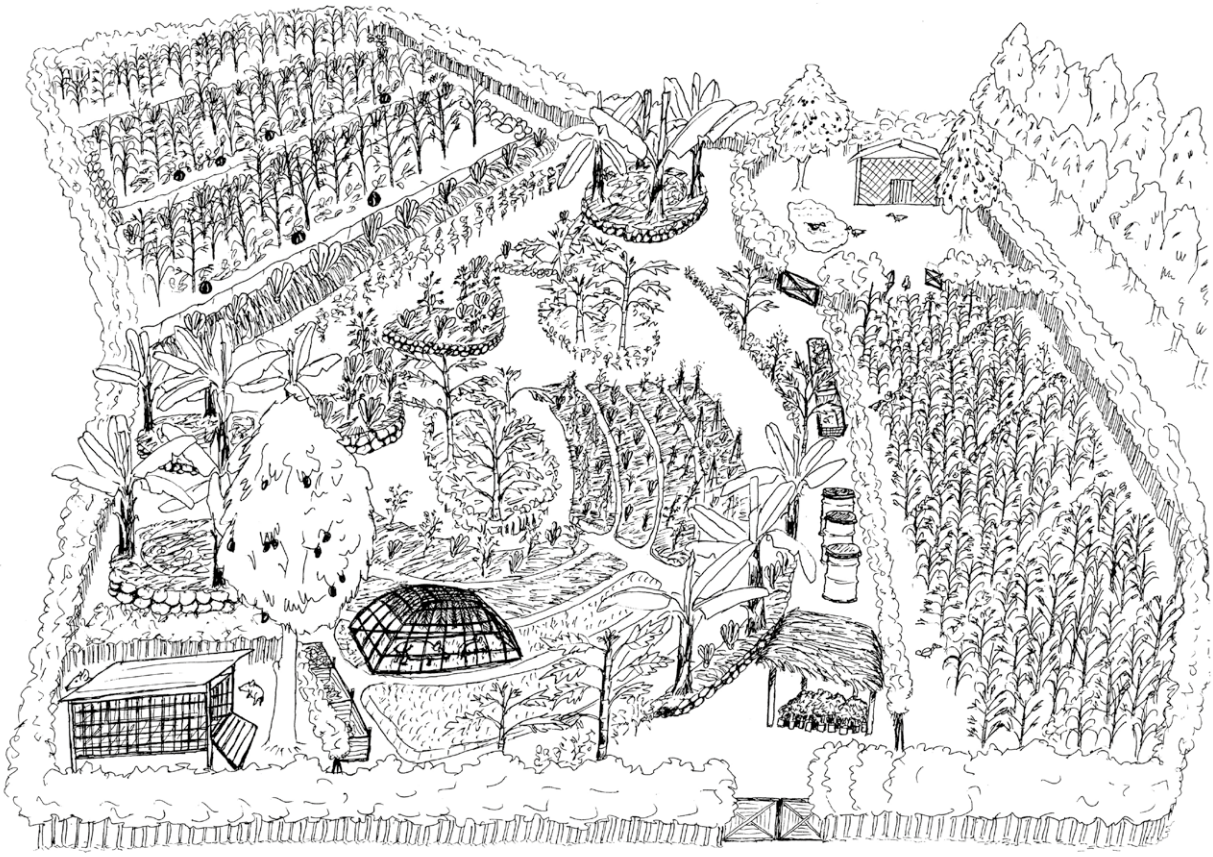
Most importantly, gardens beds need to be:

- Functional
- Easy to use
- The right width so you do not have to step on them
- Able to retain and build soil

Read the next section–Garden Bed Designs–for detailed descriptions of many different types of garden beds.



Different garden bed shapes

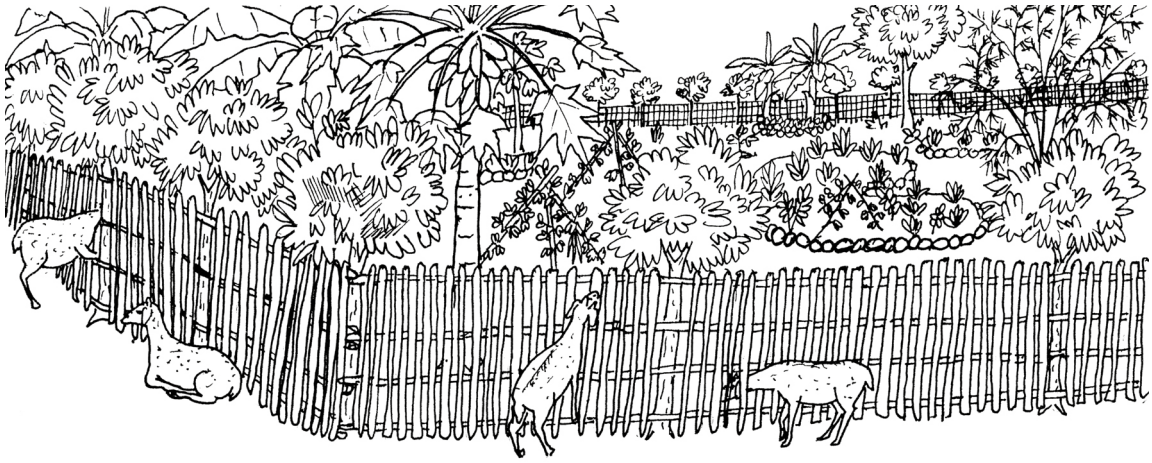


Many different garden bed shapes and designs

FENCES

A fence is essential to prevent animals from eating your precious vegetables.

Remember that fences are multifunctional. If you use one fence for two areas, you are saving time, labour and, resources. The quickest and easiest way to make a fence is to plant a living fence. Living fences can be made from many different plants and trees, and provide many products.



Keeping out hungry goats

Living fence construction methods:

- You may need to build a temporary fence while the living fence grows.
- You can include living plants/trees as the posts for a fence.
- If you already have a fence, you can plant a living fence next to it as a long-term replacement.

Living fence using many different plants

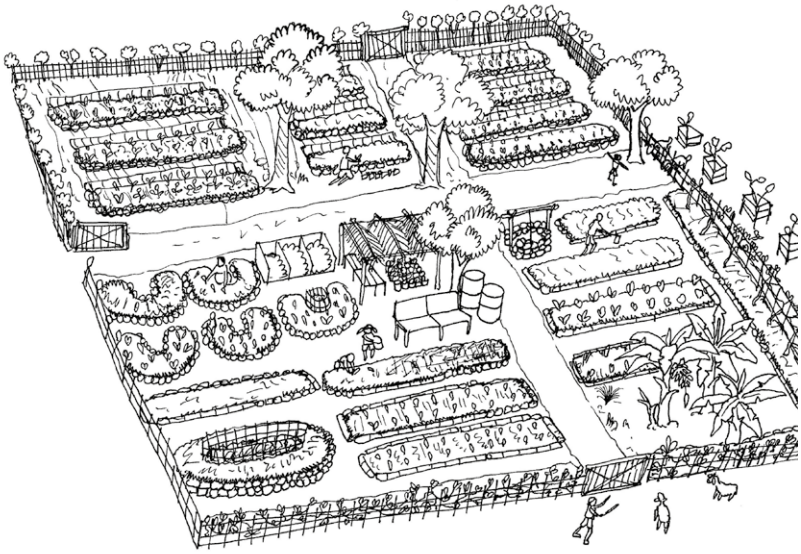
FENCE MATERIALS

Living fences: legume trees, small clumping bamboos, food producing trees, animal fodder producing trees, compost and mulch material producing trees, natural pesticide producing trees, trees with thorns and sharp leaves to prevent animals, thick grasses, cactuses, and many others

Other materials: stone, wood, bamboo, old fishing net, old tin roofing

Your fence will also provide many other functions:

- Windbreak
- Trellising for vines including beans, gourds, cucumbers, and passion fruits
- Shade
- Small animal and bird habitat
- Erosion control



Fence integrating living legume trees

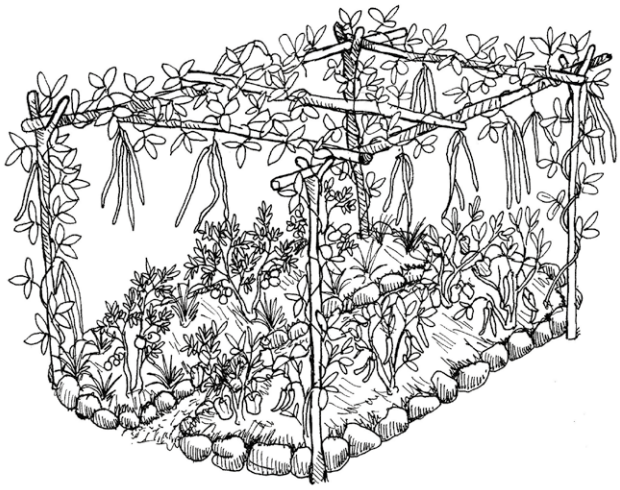
GARDEN STRUCTURES

Garden structures promote productivity, create new microclimates, and make your garden more beautiful. They can be permanent structures made from long-lasting materials or simple moveable structures. What you decide depends on your resources and needs.

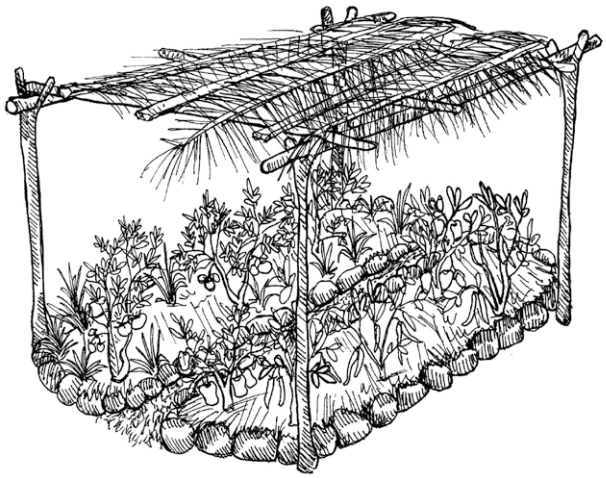
TRELLISING

Trellising provides structures for vines, cucumbers, tomatoes, beans, and other plants.

- They allow more to be grown in a smaller space.
- They reduce fungus and mould problems, because they allow better air flow, and reduce rot problems, as the fruit/vegetable is not touching the ground.
- They create semi-shade spaces for vegetables that like semi-shade.



1. Trellising in the dry season



2. Shade in the hot period before the wet season

HOT PERIOD SHADE

Provide shade during the hottest time of the year when vegetables get stressed. The standing poles around the garden can be permanent. When the cool dry season finishes and the days get hotter, connect the poles with split bamboo frames and tie on coconut leaves or other big leaves that provide some shade. Total shade is too much; semi-shade is best. Plants that benefit include eggplants, capsicums, chilies, tomatoes, and green-leaf vegetables.

Benefits:

- More plants survive through the hot period
- It reduces plant stress, providing better production when the wet season starts
- It extends dry season productivity
- It saves water

SCULPTURE AND OTHER ART

Sculpture and other art make a family garden more beautiful, more welcoming, and a better place to work. It is also important for displaying traditional cultural patterns. Food feeds the stomach, beauty feeds the soul!

Compost and compost resources storage

Your garden needs an area for making compost and liquid compost, and storing the materials for making compost. This can include a two or three bay compost system, liquid compost containers, and an area next to them for storing manures, weeds, garden waste, and mulch materials.

SMART IDEAS:

- Place the compost and resource storage area where there is easy access in and out of the garden, near a water supply, and next to your nursery. This will save you a lot of time and energy!
- Later on in this chapter's garden bed design section, learn techniques for combining compost with your garden beds.

Liquid compost drums

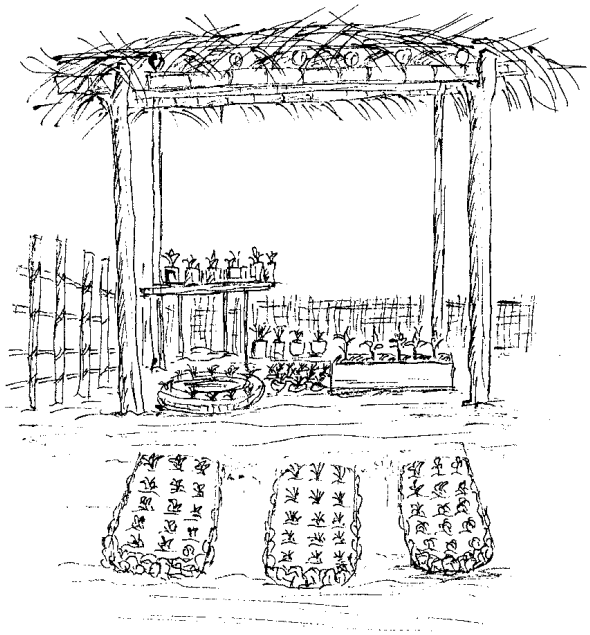
Small nurseries

It is very easy to make a small nursery out of cheap and natural materials. You can even make small moveable nurseries. A nursery is important because plants need more care when they are young. If you look after seedlings, the size and quality of vegetables will increase.

Nurseries need to provide:

- About 30 to 50% shade, especially in the middle of the day: coconut palm leaves or other palm leaves that have been split provide the right amount of shade.
- Protection for seedlings from animals
- Soil that provides nutrients and easy root growth

When you grow seedlings in vegetable beds, mix in rice waste, sand, compost, and dry, aged manure with the soil to help the seedlings grow better. See Plant nurseries (**Ch 12**) for more details on potting mixes.



Small garden nursery

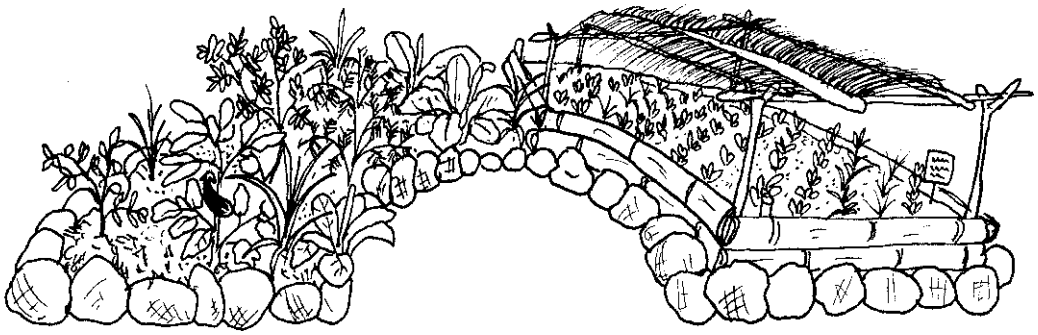
Different examples of potting mixes:

1. For vegetable seedlings – 30% compost/dry aged manure, 30% soil, 30% sand, 10% rice waste
2. For cuttings and trees – 25% composted manure, 25%rice waste, 25% sand, 25% soil

Soil from the ground does not make good potting mix for nurseries and must be mixed with other materials.

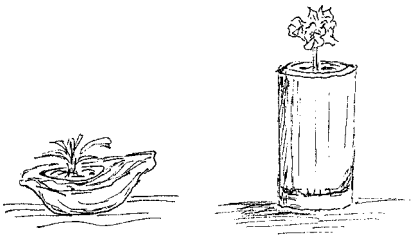
Sand and rice waste provides good drainage and aeration for easy root growth. Compost and dry, aged manure provide nutrients.

Make temporary midday shade for the first three to four weeks of the seedling's life.

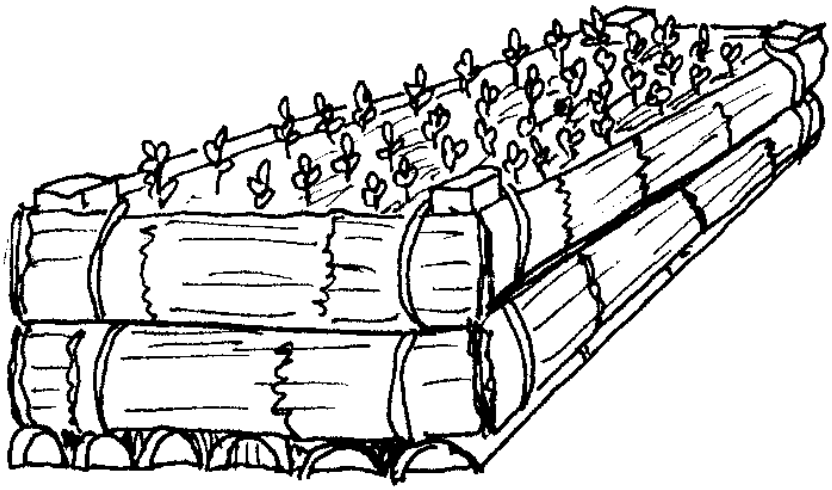


Seedling nursery in a garden bed

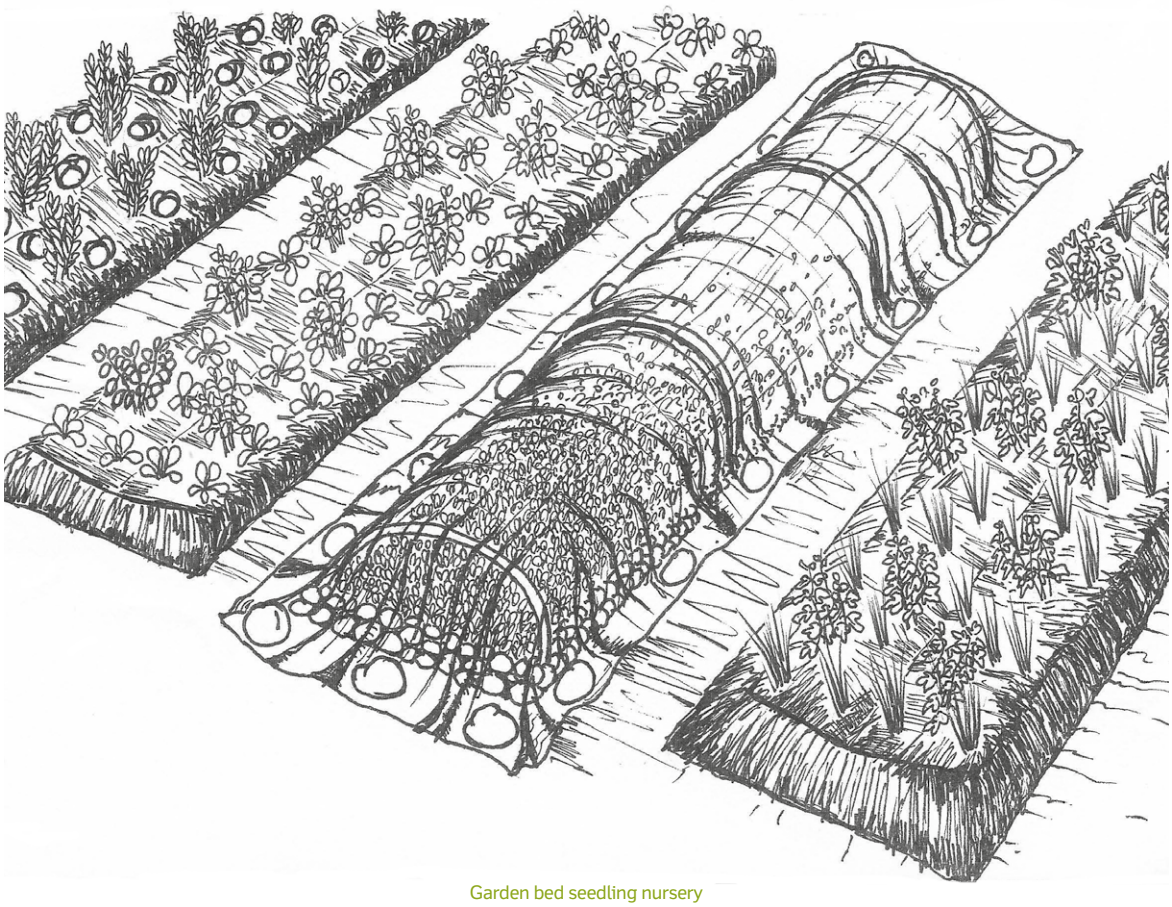
Banana leaves make excellent small containers. They are easy to make and free. Grow one seedling in each banana leaf container. When it is time to plant the seedlings, simply place the whole container in the ground and the roots will grow through the banana leaves. Easy!



Banana leaf, coconut and bamboo seedling containers



Look up Plant nurseries (**Ch 12**) for more information and techniques for small and large nurseries.



Garden bed seedling nursery

Trees, shrubs, and flowers

With or without a fence, gardens improve when surrounded with small fruit trees, perennial plants and small trees, legumes, and flowers.

These provide wind shelter for the garden, food for humans and animals, mulch and compost materials. The wind shelter increases production, and growing some mulch and compost materials close to your garden makes maintenance and fertilising much faster and easier.

Pollinators and pest predators, such as birds, wasps, bees, other helpful insects, and spiders, will also be attracted into your garden. Increased pollination of fruit and vegetable flowers leads to more fruit or vegetables per plant. Pest predators eat pest insects in your garden and help to reduce pest numbers.

Flowers and herbs are especially important to include because they also add beauty, fragrant smells, and food (many petals and leaves are edible) to the garden, as well as attracting pollinators and pest predators.

Ponds

Ponds are beneficial in many ways.

You can use them to raise fish and prawns or grow vegetables, such as taro, watercress, and water spinach.

Placing a pond or two near the garden provides a home for frogs, small lizards, and insects that eat many pest insects in the garden. Birds are attracted as well. You can produce mulch and compost material quickly and easily.

Gravity fed and nutrient rich irrigation from a fish pond

The ponds can be part of an irrigation supply, or fed from an irrigation supply or a spring.

Ponds can be constructed to grow water vegetables, compost material and mulch in the wet season, and left to dry out in the dry season.

Beware: Chemicals, such as pesticides and herbicides, kill a lot of plant and animal life in ponds and aquaculture systems.

SMART IDEAS: About mosquitoes

- Collect extra water in the wet season into ponds using trenches and swales. This prevents water just lying on the ground. Mosquitoes will only be able to lay eggs in the pond.
- The fish, frogs, small lizards, and other pest predators that live in and around the pond will eat mosquito eggs and larvae in the water.
- If mosquito larvae are still present, place one cup of neem fruit/seeds and four cups of neem leaves in a cloth with a rock, tie it up and sink it to release the neem oil slowly into the water. Replace the neem every three months.

Therefore you reduce mosquito numbers, diseases from mosquitoes, and everyone's health will benefit.

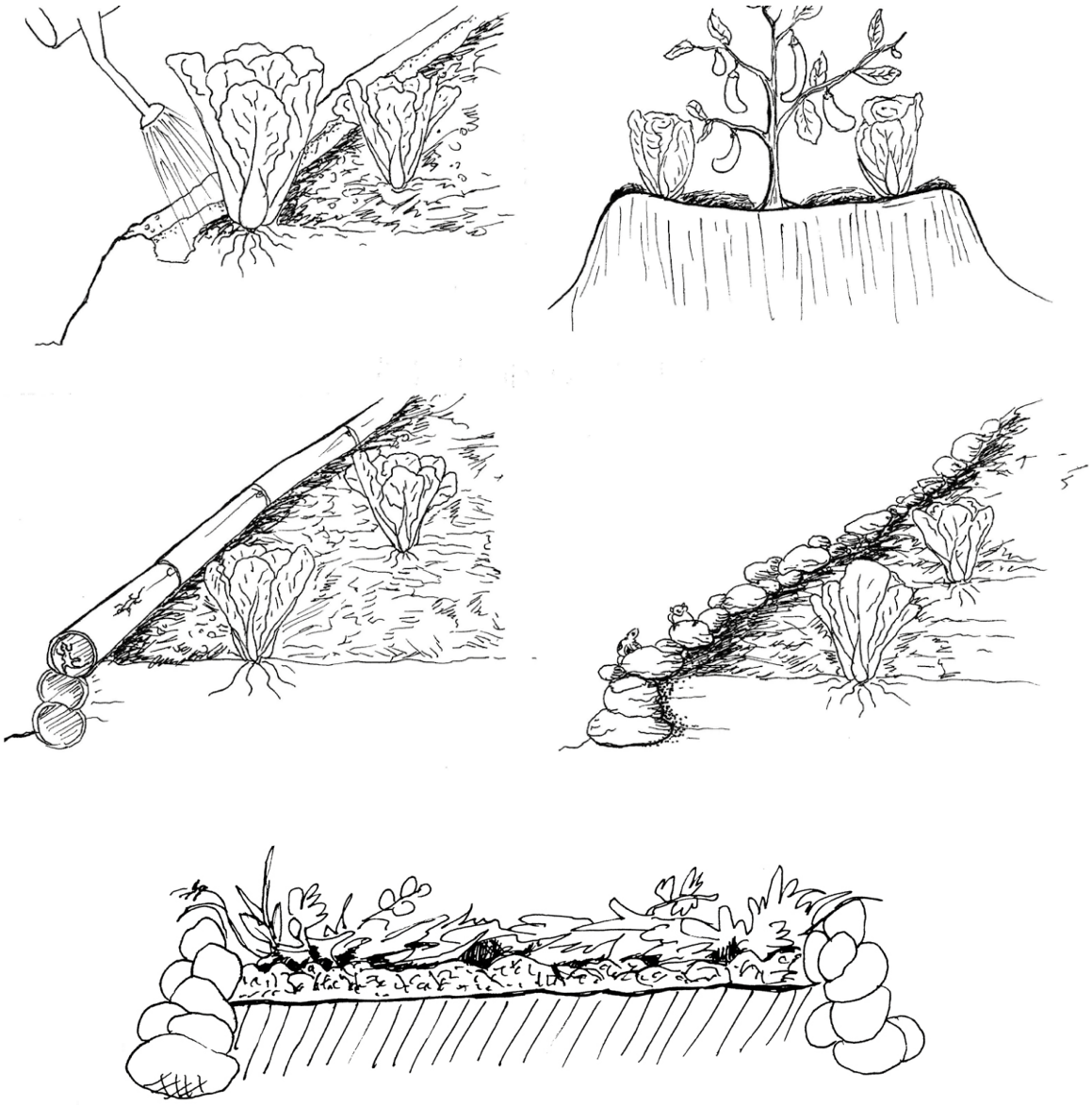
GARDEN BED DESIGNS

RAISED BEDS

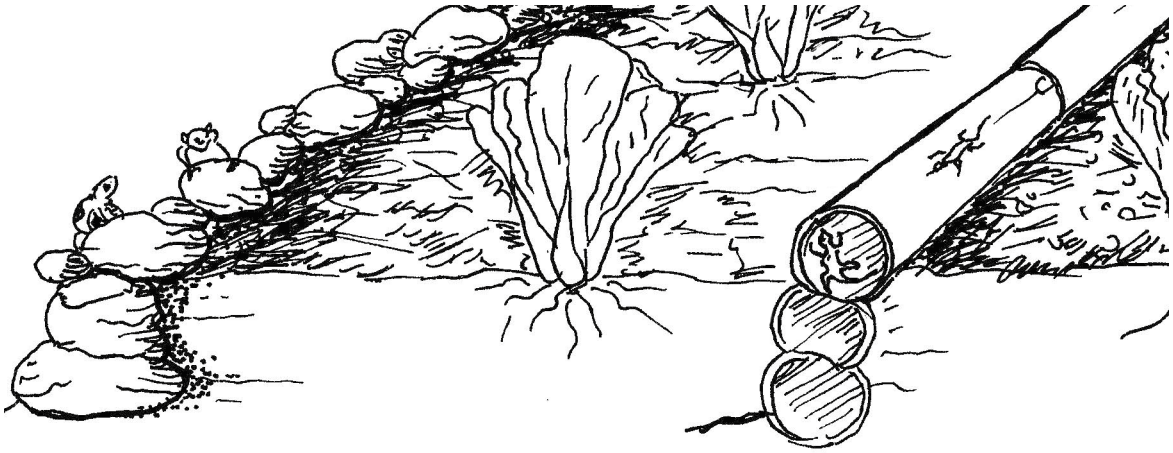
Good garden bed design improves soil quality and soil volume every year. On flat or gently sloped land raised garden beds are the best method for growing food. They are a key to improving production, especially in the wet season, because rain water drains through and away.

Raised beds are even better when:

- They have rocks, bamboo, wood, earth bricks, etc. around the edge as a border.
- They have a water-catching edge to hold in the soil, water, and mulch.
- They are made with a very slight slope from the edges to the middle of the bed with a small drain or compost trench in the middle.



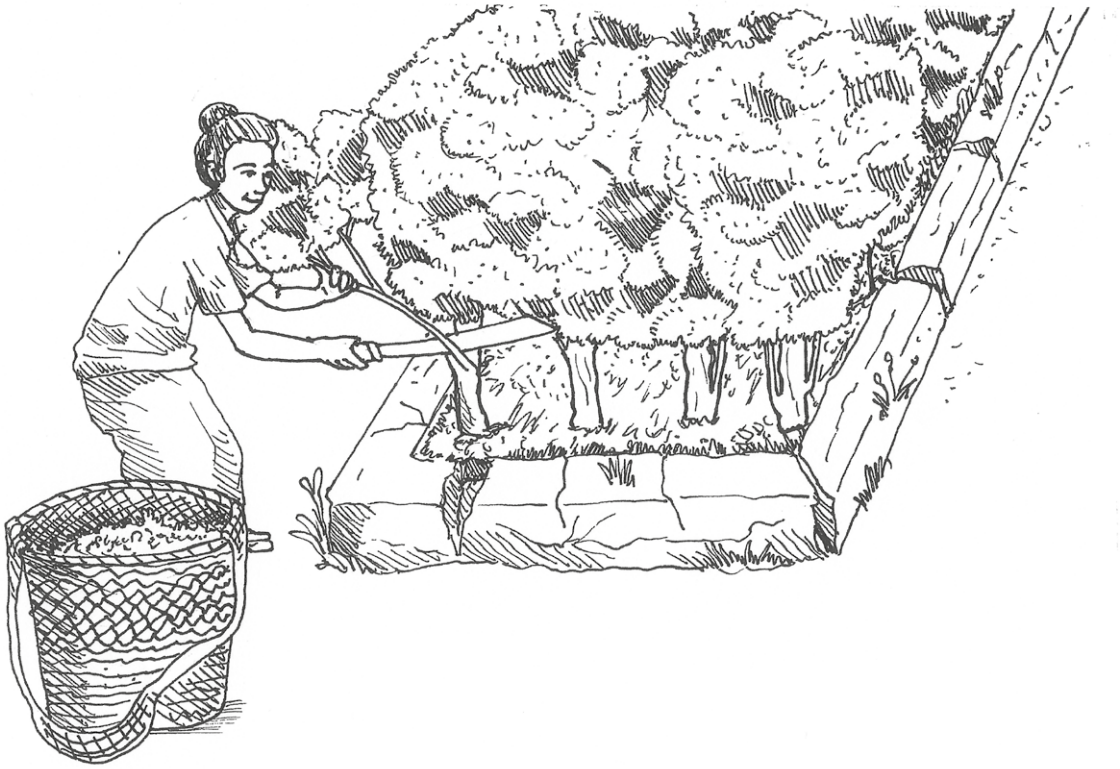
Different raised beds showing good water management strategies



Garden borders provide homes for beneficial small animals

A border also allows soil volume to increase and provides a valuable home for pest predators.

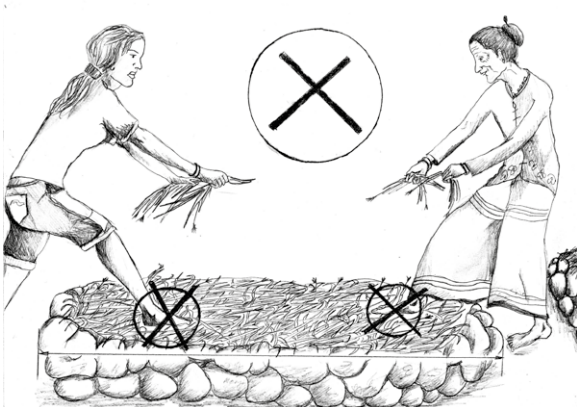
Earth brick borders are easy to make if you have enough clay in your soil. In the dry season mix soil, dried and cut grass and water together and compress it into mounds where you want the borders to be. Flatten the top of the mound to compress them to the required height and width, and leave them to dry. When they are semi-dry, cut the sloped sides off with a sharp machete or shovel to create the vertical brick shape: 15cm high and 10 to 15cm wide is good. Cut slits every 40 to 50cm to create a brick style and allow excess water to drain out in the wet season. Thanks to HIAM health staff, Dili.



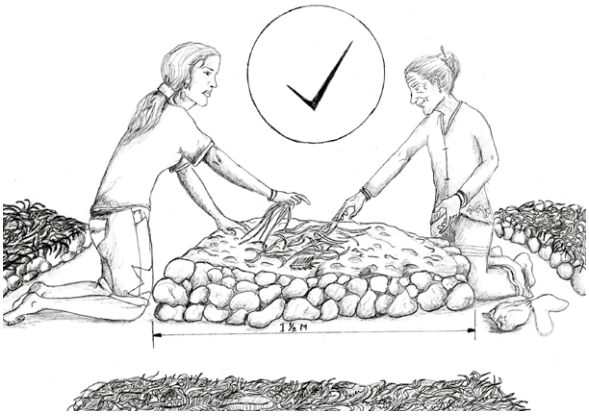
Earth brick garden borders

GARDEN BED WIDTH

Make your raised beds wide enough to be able to retain water, but small enough so you can reach all of the bed WITHOUT STEPPING ON IT: between 80cm to 120cm wide is good. This prevents soil compaction when people stand and walk on the beds. Soil compaction reduces water retention in the soil, and makes root growth and garden management much harder, which all lead to reduced production.

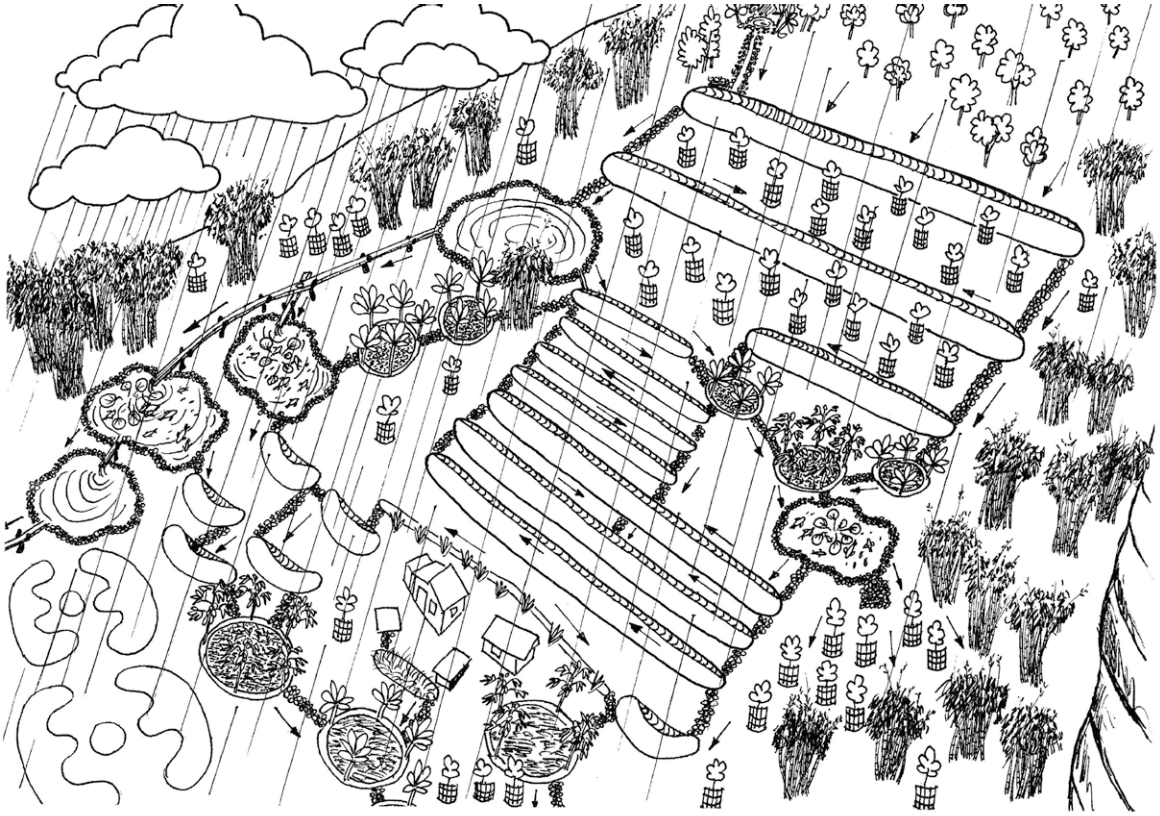


1. Garden bed too wide



2. Garden bed good width

On flat land choose whatever shape you want for the garden beds, as long as they are a good width and easy to use and maintain. On sloped land the garden beds should follow the land contour.

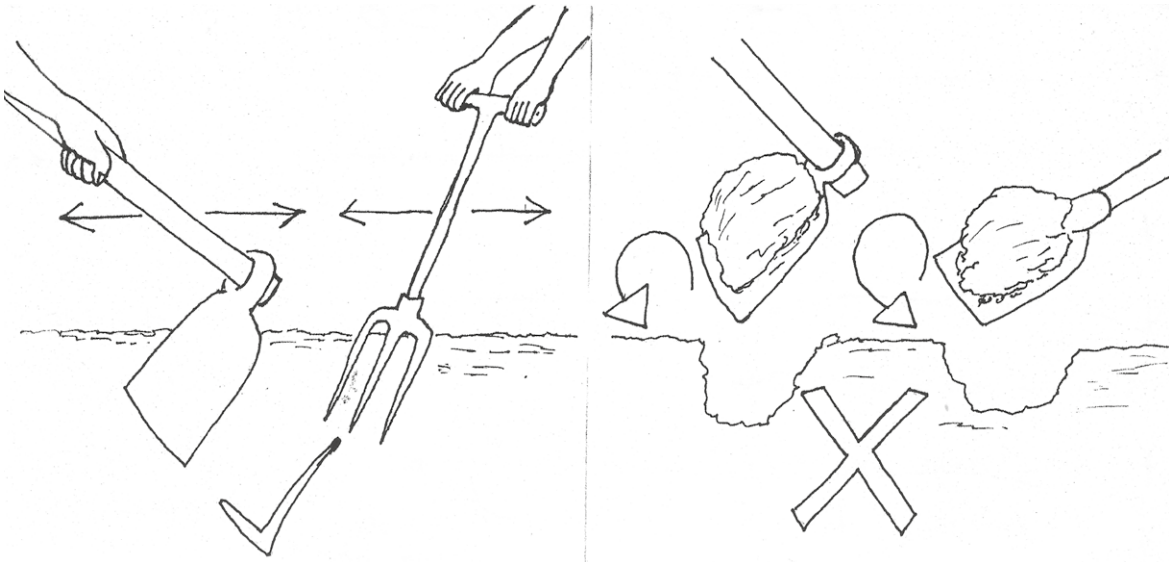


Different garden bed designs for sloped land

If you have to dig the soil over when creating a garden bed, do it **once** only. With good techniques and lots of compost, mulch and organic matter, digging will be minimal from then on.

Digging the soil every year exposes the soil underneath. This will temporarily add air and make the soil softer but it will cause a lot of problems too:

- Fungus in the soil that damages plant roots will spread when the soil is dug and turned.
- Weed seeds in the soil germinate after digging the soil, competing with your vegetables and creating more maintenance work.
- It damages the soil structure, which reduces water retention and nutrient availability.
- Rapid loss of organic matter occurs, which the crop and soil organisms rely on for feed.
- It greatly reduces soil micro-organism numbers because their habitats are damaged.



SMART IDEA:

Each season when you are preparing your garden beds for planting, turn the soil as little as possible. If you need to loosen the soil, use a garden fork, push it into the soil, and move it back and forth a little. This loosens the soil but does not turn it over, aerating it without creating all the problems described above.

Read about the many different garden beds that are described next. Use these techniques to create new gardens or to improve your existing garden beds. Choose techniques that suit you and your land best. Make sure you use the site analysis and garden design techniques first, then redesign your garden beds.

No-dig garden beds

This is a type of raised garden when the bed is built up, with no digging required!

Building your garden beds up with lots of manure, compost and leaves and dry grass will create nutrient-rich garden beds that are also full of good micro-organisms. It is similar to building a small compost heap and is an excellent method for quickly making good soil where the soil is very poor.

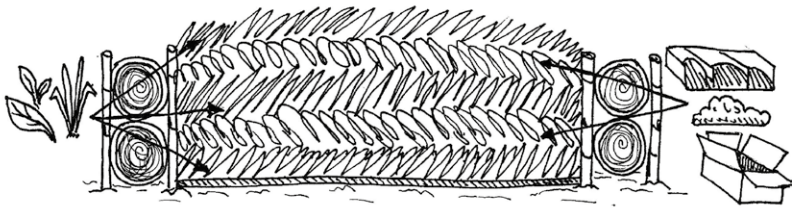
IMPORTANT: do not build no-dig gardens on soil that contains running grasses that spread underground or weeds that grow from bulbs. These types of weeds cannot be killed easily and will create problems in the future if they are not first dug out and removed. (see the 'Weed maintenance' section for more information).

Steps for building the garden bed:

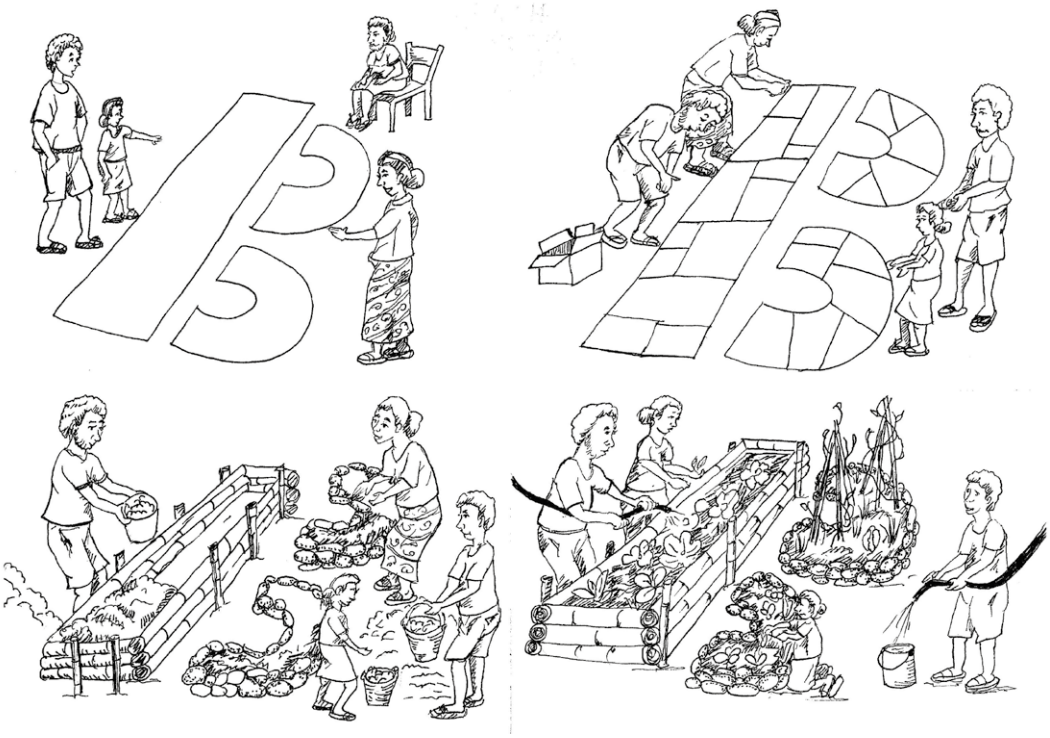
1. Mark out the edge of the bed following the ideas for good garden bed design.
2. Loosen the soil where the garden beds will go, but do not dig it over or turn it.
3. Lay down sheets of taro leaves, banana leaves, newspaper or cardboard, covering the ground completely. This reduces weed growth.
4. Add a layer of dried and cut grass and dry leaves, 10cm thick. Mix in some washed seaweed if you have some.
5. Add a layer of compost or dry and crushed animal manure, 5cm thick.
6. Repeat Steps 3 and 4 again, and cover the garden bed with a 5cm layer of mulch.
7. Add a garden border if you have the materials.

It is now ready to plant! Add a big handful of compost mixed with soil for every seed and seedling that you plant so they have soil for the new roots. The no-dig garden needs to be well watered, especially for the first two weeks.

This is one version of no-dig gardens.



Cross section of no-dig garden bed



Step by step no dig garden beds

Another is to leave Step 3 (layer of taro leaves, banana leaves, newspaper or cardboard) until the end and cover it with the final layer of mulch. This works very well too.

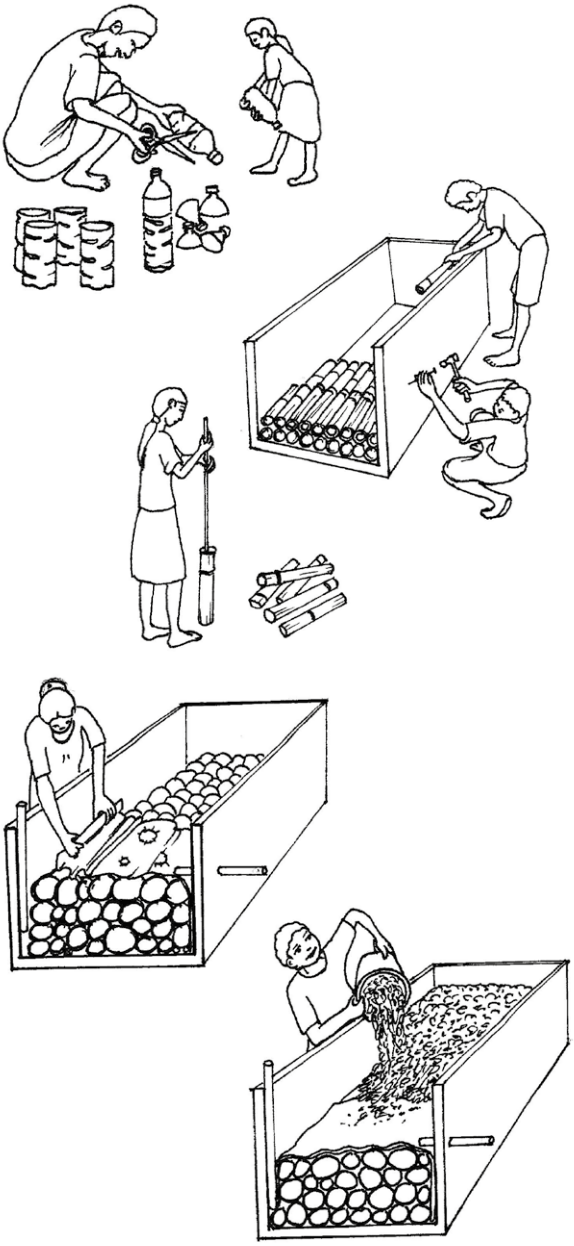
The African keyhole garden and spiral garden are also no-dig gardens and are described later this chapter. Experiment for yourself to find what works best for you.

Drawing and making a no dig keyhole garden bed

WICKING GARDEN BEDS

A wicking bed is a self-watering garden bed. It is made from a large container with no holes in it. All the materials you need to construct it can be recycled, so it is very cheap and good for the environment too! It consists of a water-well in the bottom third of the pot and soil in the top two-thirds. It is great for vegetables and herbs that you use every day. It is given the name 'wicking bed' because the water is drawn up from the well at the bottom to the soil at the top, like a wick.

Wicking beds are much better than normal pots because when the well is full, the watering is self-regulated for up to a week. The roots of the plants will use as much water as they need, and there is no evaporation and no water for weeds. This makes it much more water efficient and great for areas where water is precious. As a wicking bed grows a lot in a very small space, it is great for urban gardens, balconies, verandahs, and even inside the house if there is enough sunlight.



Step by step wicking bed construction

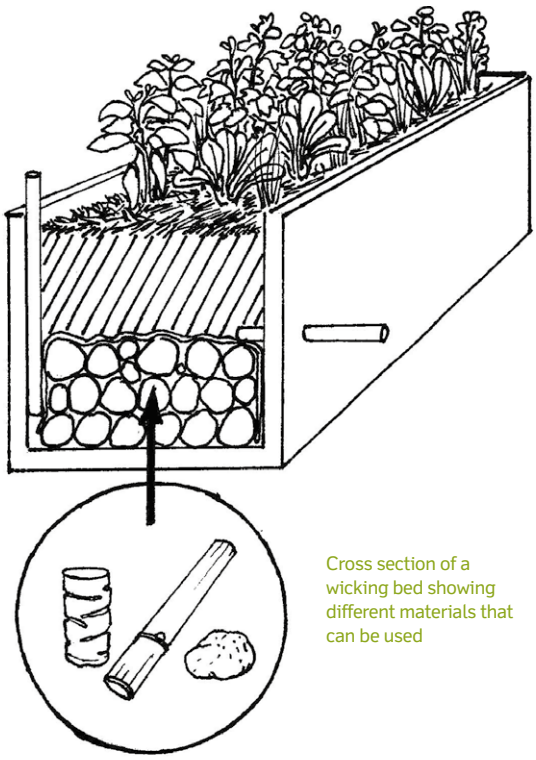
To make it you will need:

- A large watertight container: this could be a plastic or metal drum cut in half, a foam box, an old fridge or any large container that can hold water.
- Something to make a space for water to fill the bottom of the container and still hold the soil up. Old plastic or glass bottles are great and this turns rubbish into something useful. Cut the tops off the plastic bottles first. Old wire mesh or small rocks can also be used. Bamboo poles cut into sections with the inner node knocked out are also great. Fill to a third full.
- Add two handfuls of charcoal, if available, to spread around the bottom. It will help keep the water clean.
- Old wire mesh (only if you use plastic bottles in the bottom): use enough to cover the layer on the bottom.
- Old material–thick material, such as hessian. Use enough to cover the bottom layer and fold down the sides to the bottom of the container.
- Some plastic pipe or tube, old irrigation pipe is great. Cut a piece so that it is the same height as the container. Place it in a corner vertically so that it is almost touching the bottom. Cut another piece 20 to 30cm long. Make a hole in the container at the same height as the material and so that the pipe fits neatly through it. Put the pipe through the hole horizontally, so that 5 to 10cm sticks out at the side. Cover the end with mesh, hessian or material to stop mosquitoes from entering.
- Soil, but do not just use soil from the ground as it will get too compact and not have enough air or drainage. Use up to 50% soil and mix it with 25% compost or aged dry manure and 25% dry rice husks, coffee husks or coconut husks. Fill the container to the top with this mix. Make sure that the top of the pipe in the corner is not covered.
- Mulch to cover the soil.

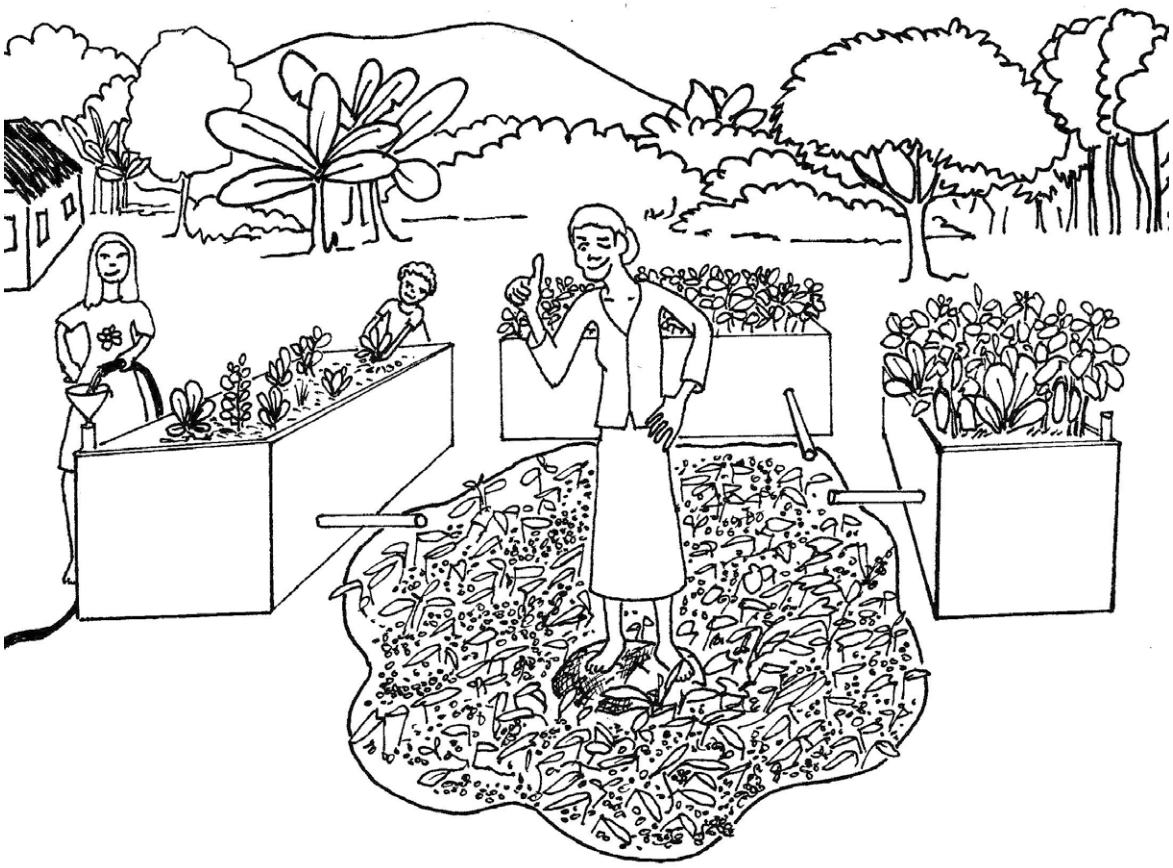
How to use it:

The vertical pipe in the corner is the watering pipe. Pour water into the pipe and the well in the bottom slowly fills. When it is full the water comes out of the horizontal pipe. This is the overflow pipe, and, as a result, the wicking bed can never be overwatered, even in the wet season. The water in the well is slowly drawn into the soil up via the wicking process. Plant your vegetables and herbs in the bed. Water them directly once to help them settle. After that they will use the water from the well. Choose seasonal vegetables and herbs in the dry season and plants that like wet soil in the wet season.

After two years it is recommended to remove all the contents and start again, because the bottom section will slowly fill with soil and have no space for water. Also, the bamboo and plastic bottles will degrade and need to be replaced.



Cross section of a wicking bed showing different materials that can be used



SMART IDEA:

Overflow pipes can be made longer and run into a pond.

SPIRAL GARDENS

A spiral shape is an easy and beautiful way to create a garden bed with different heights.

Benefits:

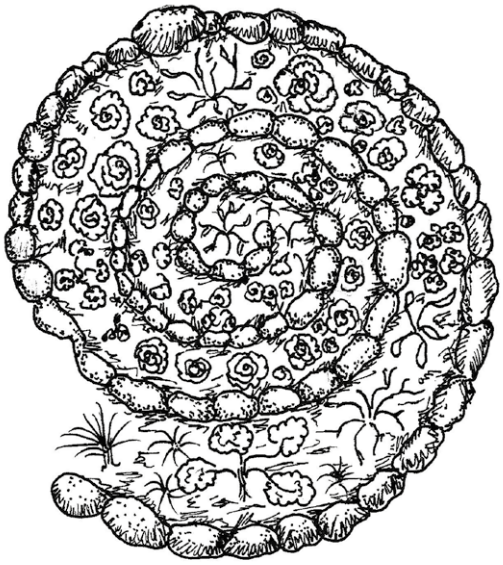
- Changing the height of a garden bed increases production and the planting area.
- Different heights allow for more root growth and better access to sunlight.
- Put plants that need good drainage and drier soil in the middle so they can grow well, even in the wet season.
- Put plants that like more water around the edge.

You need rocks or old cement blocks to create the edge and spiral shape, and soil, dry manure and compost to make the raised spiral.

Spiral gardens are another good garden bed design for urban areas.

Steps:

1. Mark out the outer circle of the spiral: 1.5m to 2m diameter is good.
2. Loosen the soil where the garden beds will go but do not dig it over or turn it.
3. Cover the ground with taro leaves, banana leaves, newspaper or cardboard to help prevent weeds.
4. Place the rocks on the outer circle until the circle is almost complete.
5. Add soil/compost/dried animal manure until the bottom layer is full.
6. From one end of the outside edge continue the line of rocks in a spiral shape toward the middle. The rocks/blocks will slowly rise as they are placed on the new soil.
7. Add more soil/compost/dried animal manure.
8. Continue until the spiral is complete.
9. Plant out your vegetables and herbs.
10. Add a thick layer of mulch and water well.



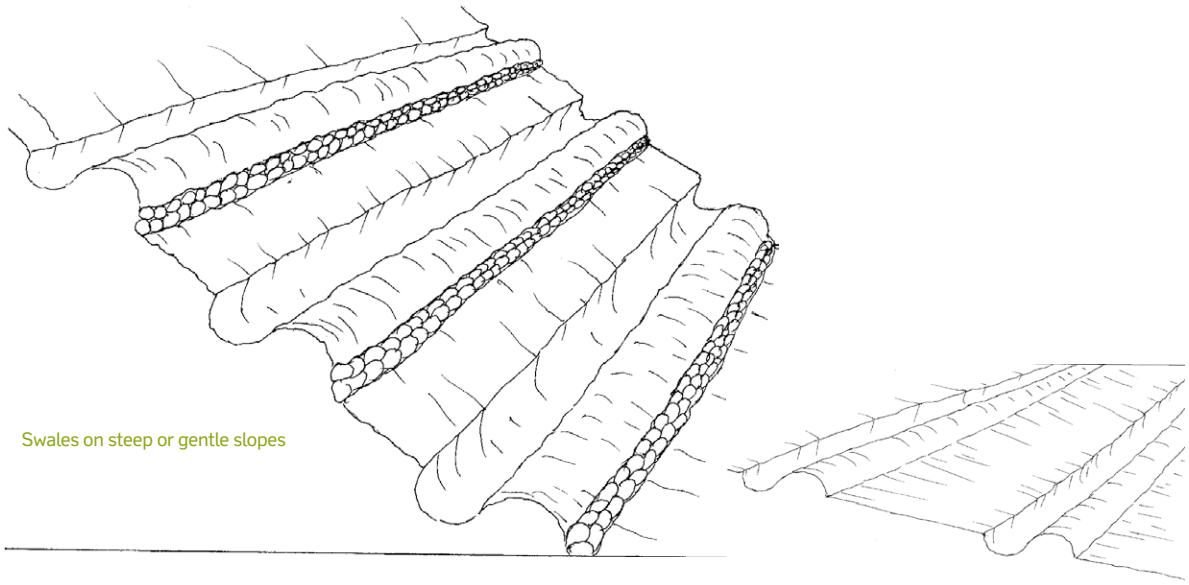
Spiral garden shown from above

Spiral garden side views

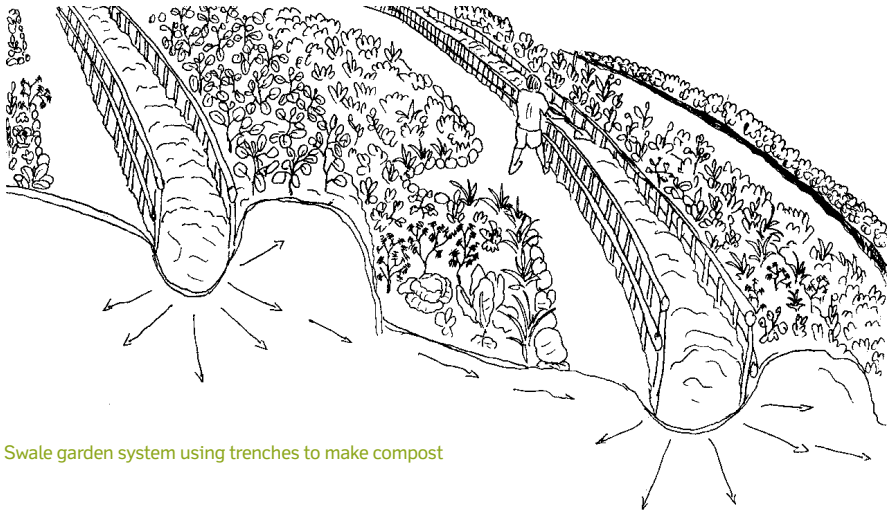
SLOPING LAND GARDEN BEDS

SWALES

Swales are an excellent way to make vegetable gardens on sloped land, even for small family gardens. You can use different patterns on gentle sloped land.



Swales on steep or gentle slopes



Swale garden system using trenches to make compost

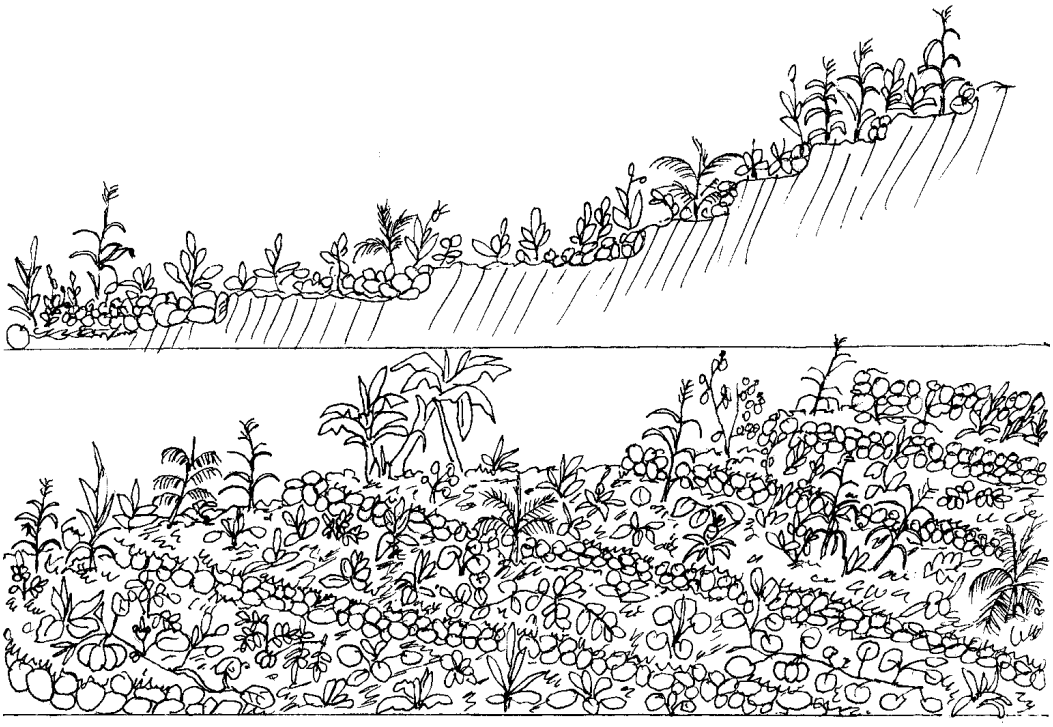
Swales prevent erosion, help improve your soil, and hold all water and nutrients in the ground. The swales and terraces need to follow the shape of the land so that heavy rains do not create problems. For vegetable gardens, smaller swales are usually better. On steep slopes make small swales about a metre apart. For gentle slopes make bigger swales about two metres apart. Look at Permaculture design strategies and techniques (**Ch 3**) for instructions on how to make swales and terracing.

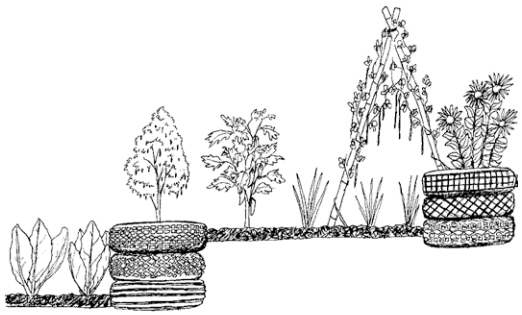
Swales will give more planting area and also provide different microclimates. The bottoms of the swales are wet and sometimes full of water in the wet season so you can grow water-loving plants, such as water spinach and taro. The top and back of the swale are drier so you can grow other vegetables and plants.

On slopes the pathways can be the trenches of the swale system to reduce erosion. Or the trenches can be used to make compost in.

TERRACES

Terraces are like swales because they also follow the contour of the land. They are cut into the land and usually have stone or clay walls to hold the land in place. The land between the walls is flat.





Terraces take a lot more time, effort and sometimes money to make, but create very productive land. They are better than swales on steep slopes for small family gardens. Terraces are used in many countries and there is a lot of information on building and using them. Look in the reference chapter for books and internet sites.

Integrating garden swales with fruit trees and fish ponds

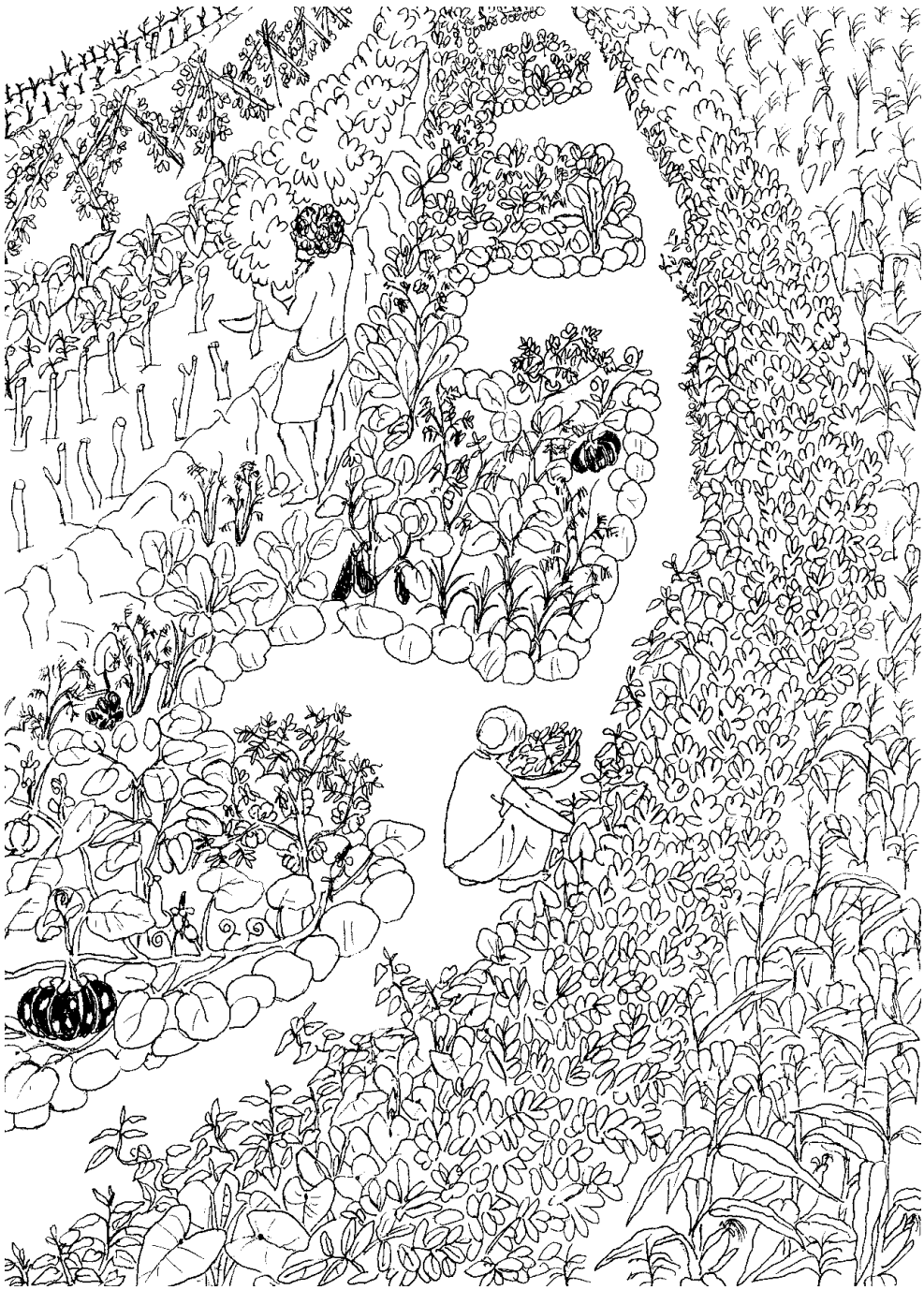
SMART IDEAS FOR SWALES AND TERRACES:

- Always build the edge of the terrace higher with rocks, etc. This prevents erosion and allows for soil to increase. It also provides room for putting mulch and compost and helps to hold more water.
- On steep slopes you need to make sure that heavy rains do not cause erosion or landslides. In areas where there are potential land slide problems, you need to plant some deep rooted trees and/or vetiver grass to help to hold the soil together. Use legume trees that do not give too much shade and can be cut back for mulch and animal food.
- There are many ways to integrate vegetable crops with fruit trees and animals. Read in Permaculture design strategies and techniques (**Ch 3**) for more examples of swale and terrace production.

WET SEASON PLANTING IDEAS

Trench: you can plant taro, water spinach, watercress and other plants that like a lot of water in the bottom and at the sides of the trench. Put plants that like a lot of water, but do not like being under water, along the edges of the trench, e.g. lemon grass.

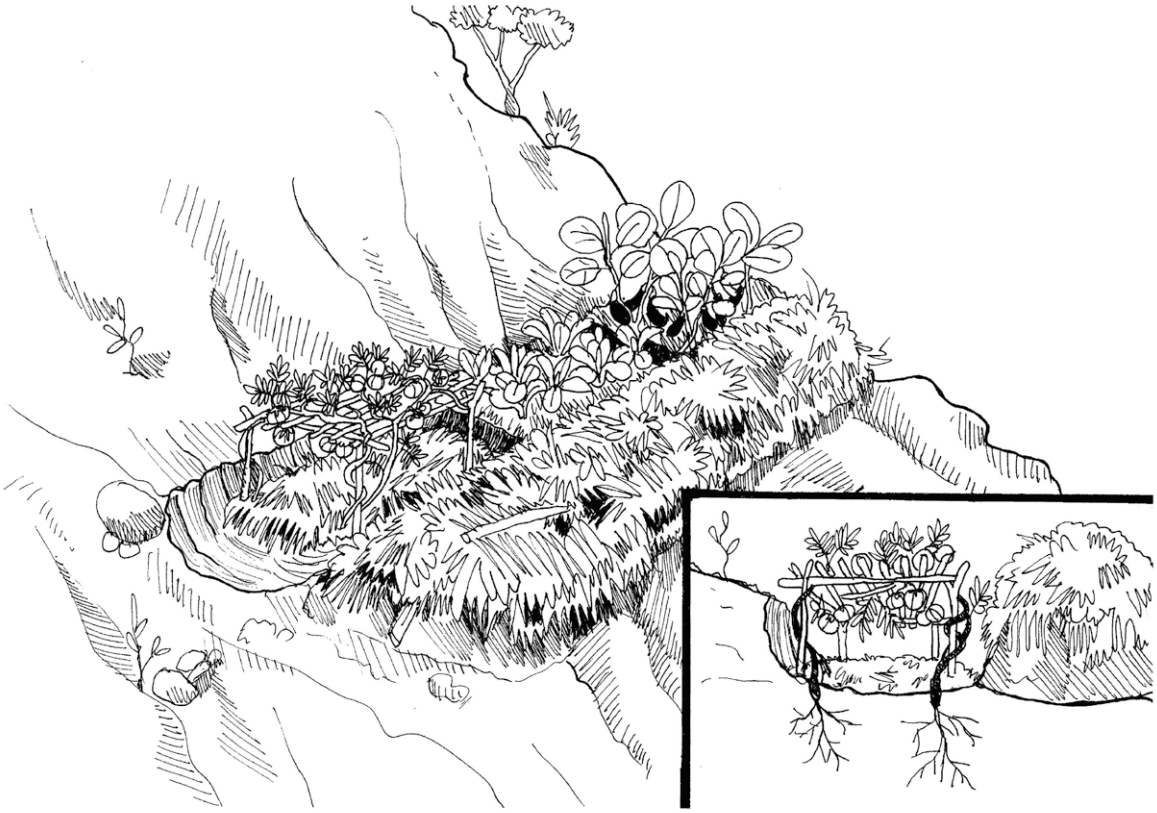
Mound: you can grow vegetables and small trees on top of and below the mound, e.g. eggplants, pumpkins, cassava, chilies, ceylon spinach, gourds, snake beans, leaf amaranth, sweet potatoes, papayas, bananas, beans, peas, cucumbers, corn, basil, pineapples, pigeon peas, peanuts, mung beans, and many more.



Intensive swale garden with keyhole gardens between the swales

DRY SEASON PLANTING IDEAS

- If a good supply of water is available, you can continue to use the same ideas as for the wet season.
- If only a small amount of water is available, the trenches can be used for vegetables and the top and below the swale can continue to grow longterm plants, such as cassava, pineapples, eggplants, bananas, sweet leaf, moringa, and so on. Or the area can be mulched and left to wait for next wet season.
- If there is no water available, some long-term crops will still grow and will grow a lot better than without swales. Mulch the land and wait for the next wet season. The growing season for these vegetables is increased because the water in the soil lasts for longer, especially in areas that have little or no water.
- In the mountains, where dry season rainfall is more common than on the coast, swales will create good conditions for year-round growing of vegetables and other plants. Over time small animals can also be integrated into the system. Remember to use soil improvement techniques to get the most benefit from the swale gardens.
- The trenches of swales can be divided into smaller beds for dry season planting, saving a lot of water. Use lots of compost and mulch as the soil will need improvement.



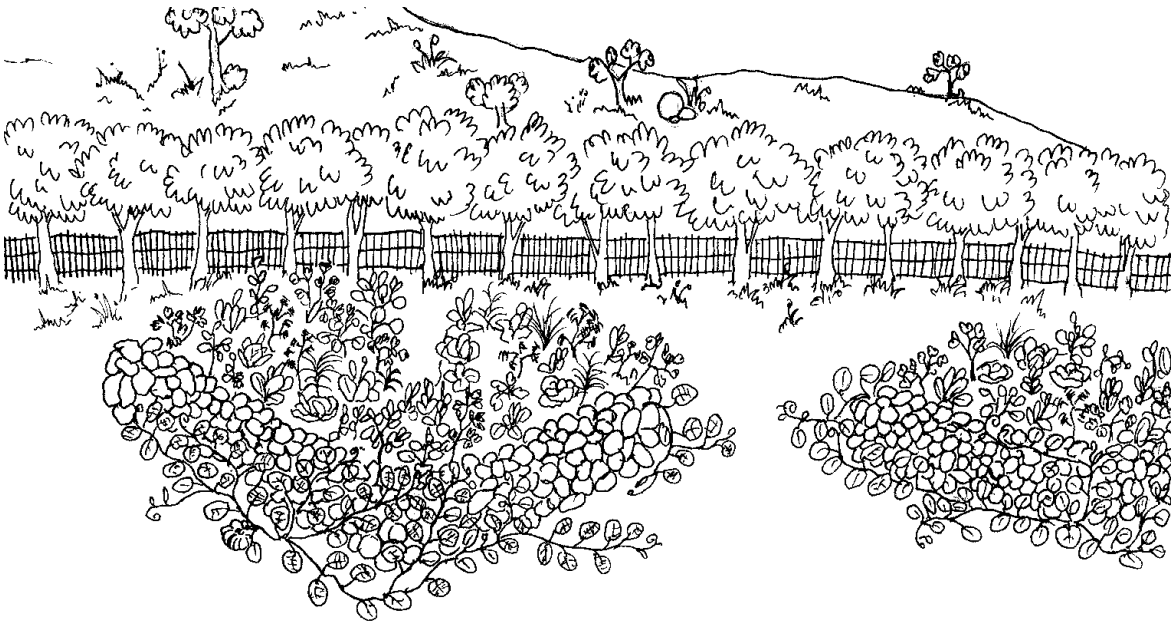
Dry season sunken garden

Dry season vegetables to include: tomatoes, capsicums, cabbages, green-leaf vegetables, zucchinis, watermelons, beans, peas, cucumbers, lettuces, and kale. Where it gets cold during the dry season, you can also grow chard, broccoli, cauliflowers, potatoes, and more.

All year leaf vegetables like moringa, cassava, tree spinach, and sweet leaf are good to plant too.

SMART IDEAS:

- Use the trench as a compost place to improve the soil quickly, the same as using compost baskets and trenches. (See the next section)
- Rock swales can be used for vegetable gardens on gentle slopes. The small terraces that are formed become highly productive growing areas.



Boomerang rock swales to improve water retention

Garden and compost integration

The following techniques are methods of integrating compost with garden beds.

They provide many benefits including:

- Increased production
- Reduced maintenance
- Improved soil quality
- Saving water
- Stronger plants that are more resistant to pests and diseases
- The food tastes better and is more nutritious.

AFRICAN KEYHOLE GARDEN

With thanks to Sendacow Foundation for the original design: **www.sendacow.org**

The African keyhole garden is a round raised garden with compost in the middle. There is an entrance–the 'keyhole'–that leads to the compost. It is designed and made so that it produces a lot of food in a small space. This technique is especially good for places that have poor soil and where water is a precious resource. It is also a great garden for urban areas and to have next to the house even if the family garden is further away, because it does not use much water.

Access to the whole garden is easy. Once you make the garden you feed and water the plants via the compost in the middle. This reduces maintenance and when the plants get their roots into the compost they grow like crazy!

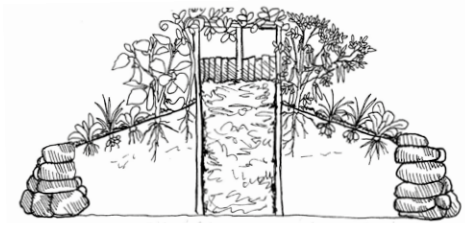
The garden has a three metre diameter, the outside edge is raised at least 50cm, and some beds have a metre high edge if it is made from rocks with cement. The compost in the middle is separated from the garden soil by sticks, palm leaf stalks or thin bamboo poles. The height of the soil in the middle should be approximately a metre high even if the outside is only 50cm high. This creates a sloped garden, which allows more sunlight due to different heights. Mulch it well to prevent erosion in heavy wet season rains.

How to make a keyhole garden:

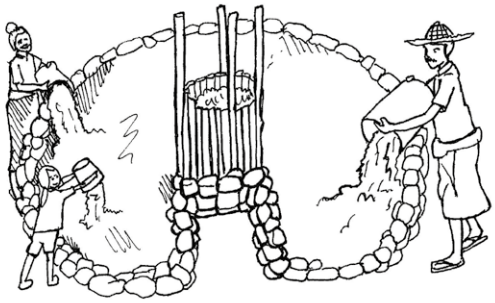
1. Identify and collect the materials you need:
   - Edge materials: rocks, cement, old bricks, bamboo, wood
   - Compost walls materials: sticks, palm leaf stalks or thin bamboo poles, thin fresh branches, grass or thin vine
   - Garden-fill materials: soil, manures, compost, rock dust, green leaves, dry leaves, seaweed, charcoal, ash (half a bucket)
2. Mark out the garden on the ground. Make a circle three metres diameter. Identify the best place for the entrance keyhole and mark this in. The entrance should be wide enough for a person to walk to the compost in the middle. Mark out the compost area with a circle with a 90cm diameter.
3. Build the compost first. Dig the sticks, palm leaf stalks or thin bamboo poles for the compost wall into the ground and secure them using thin fresh branches horizontally around and tied with grass or thin vine. Make sure that the some of the sticks used are at least 150cm high. The sticks of the compost circle next to the keyhole entrance need to be lower, about 100 to 120cm high to make adding to the compost easy.
4. Fill the compost with same materials by the same method that you use for normal compost. See Soils (**Ch 9**)
5. Start building the outside wall of keyhole garden with whatever materials you have. If you use rocks and cement, complete the outside wall before filling the garden bed. If you are using other materials you can build up a layer of wall, fill the garden, add more wall, then fill the garden, and so on until it is complete. Fill the garden bed with a soil/manures mix if possible. You can also use the same materials in the same way as for the compost area, but it will sink a lot in the first three months, and more materials will need to be added later on. Make sure that the top layer is a good layer of soil/compost 10cm thick that can be planted into straight away. As you are building the garden, keep adding water to the garden and compost. Add a final layer of mulch, and it is ready to go!
6. You can also build a grass roof for the compost to help protect it from the sun and rain. Or you can plant three or four climbing beans next to the compost that will use the compost wall as a trellis and help provide protection too.

How to use a keyhole garden:

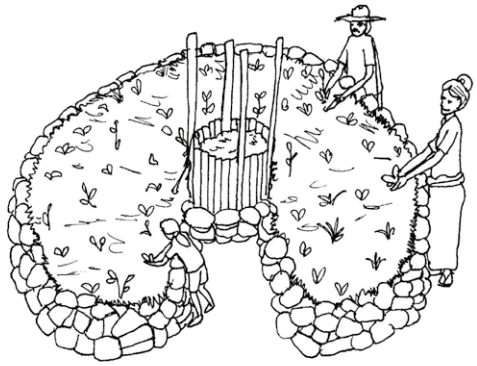
Plant your vegetables into the garden bed and water well. After a couple of weeks, when the plants are established, you can water into the compost heap. The plants quickly grow their roots towards and into the compost. Add more ingredients to the compost regularly to keep it full.



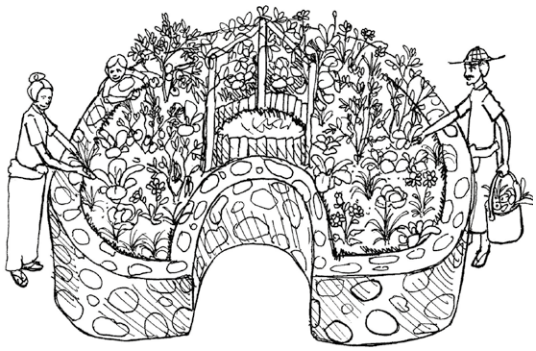
Cross-section of keyhole garden



Keyhole garden construction



Keyhole garden planting



Keyhole garden with cement and rock border

SMART IDEA:

Make a bucket of micro-organism activator, leave it over night and add it to the compost and the garden. If you have some activated charcoal–biochar–you should add a bucket into the garden as you are building it. (Read how to make both of them in Soils **Ch 9**)

COMPOST BASKETS AND TRENCHES

The following information is taken from Faith Garden Manual, written by Mindanao Baptist Rural Life Centre, Bansalan, Philippines.

Step 1:
Create garden beds that are wider than regular beds: about 1.5 metres to 2 metres is good. Dig holes in the middle of the garden bed, at least a large hand length deep, three hand lengths wide and a metre (about one large step apart). Or dig one long trench down the centre of the bed at least a hand length deep and three hand lengths wide.

Step 2:
Put bamboo stakes around the edge of the holes or trench. The stakes should be about a hand length apart and two hand lengths higher than the ground after placement.

Step 3:
Weave flexible bamboo or grasses through the stakes to make a basket or fence.

Step 4:
In the holes or trenches put:

- First – a small layer (5cm) of thin branches or dried grass stems to provide air
- Second – different manures
- Third – grasses, weeds, leaves, and washed seaweed
- Fourth – you can add ash (from wood fires only) and biochar as well, at a handful per basket or a metre of trench.

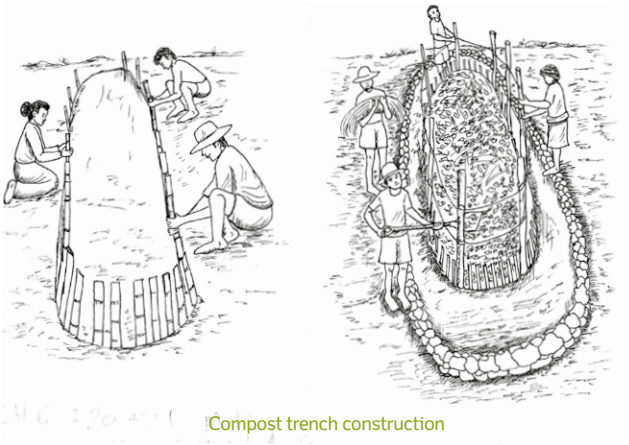
Step 5:
There is no need to turn the compost.
As the old materials decompose, just keep adding new materials in the same layers as before.

Step 6:
Plant vegetable seeds or seedlings when the materials at the bottom are nearly decomposed. To be able to plant at the beginning of the wet season, make the compost baskets or trenches a month before planting time. Plant the vegetable seedlings or seeds a hand width away from the basket or trench.

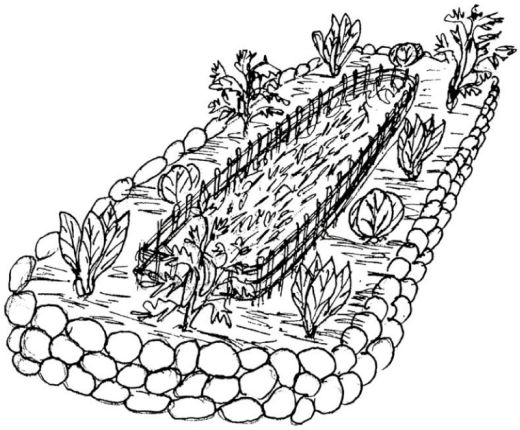
Step 7:
Water the plants for two weeks after planting. Then you can water directly into the compost baskets or trenches, not on the plants. The plants roots will grow into the baskets or trench. This improves plant growth and saves water.

Step 8:
When you harvest the crop, you can dig out the compost from the baskets or trenches and place it on the garden bed to add important humus to the soil. Then you can add new ingredients to the compost for the next crop.

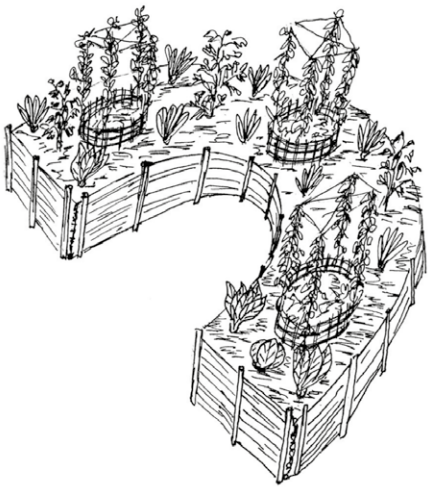
Cross-section of compost basket



Compost trench construction

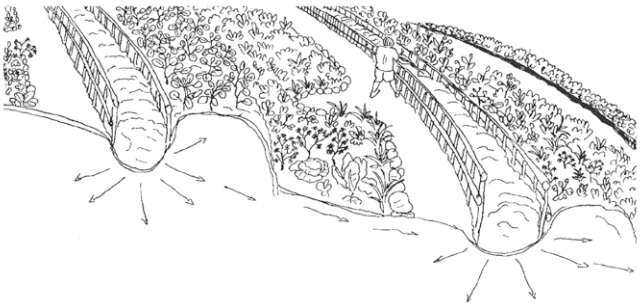


Compost basket and trench examples

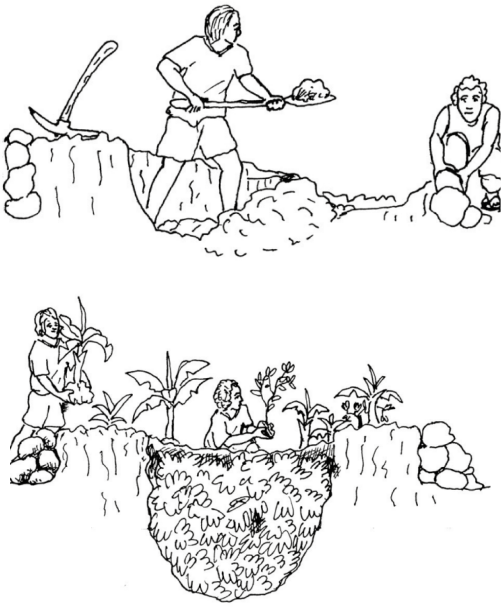


SMART IDEAS:

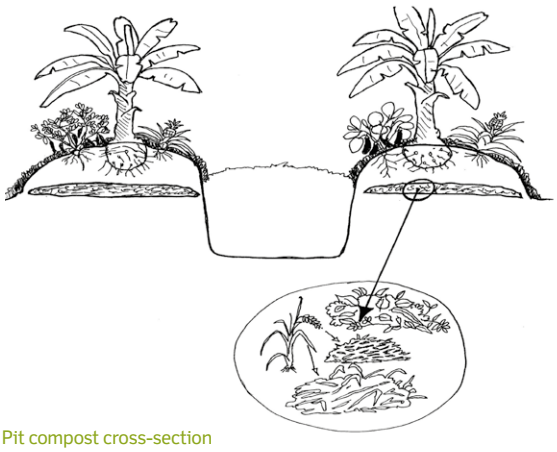
- This technique can also be used for young fruit trees.
- To allow for continuous cropping, fill the baskets or trenches at different times. You could fill each bed two weeks to a month apart.
- The basket or trench support poles can be extended much higher and used to grow beans, cucumbers, and other climbing vegetables.
- Swales can be used as compost trenches for sloped land cultivation.



Swale trenches used for making compost



Pit compost construction



Pit compost cross-section

BANANA PIT/ PIT COMPOSTING GARDEN

The banana pit/compost pit is an excellent way to feed vegetables and trees. Bananas and papayas especially like to grow around the compost pits, but do not plant them together as they compete too much for space and nutrients. You can also use the mound around the pit to grow vegetables.

First, mark out the pit circle, and around the circle place dry leaves or rice husks up to 20cm thick. Then dig the pit, with a 1 to 1.5 metre diameter, as deep as you can. Place the soil around the hole, on top of the leaves/husks, creating a mound. Plant the bananas or papayas and other plants into the mound. Do not forget to add lots of mulch.

You can add leaves, weeds, manure, rice and coffee husks, paper and other organic materials to the pit. Urine–diluted with water–is also recommended. The compost that collects in the bottom of the pit will be quickly used up by the surrounding plants. Dig it out once a year and add to the mound.

The benefits:

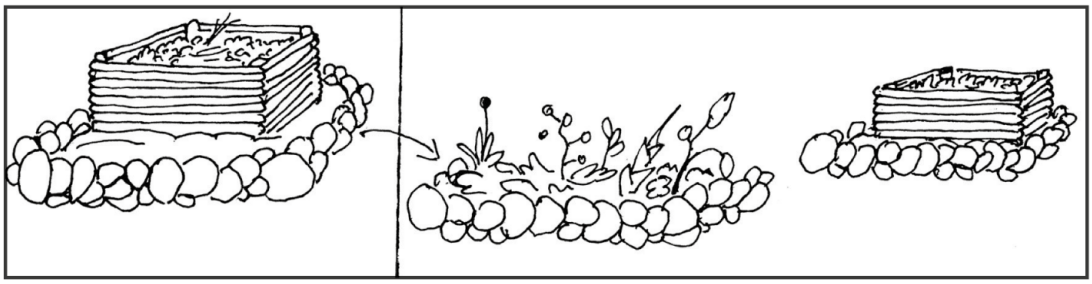
- It is a good way to deal with problem weeds and weed seeds.
- You can easily make it into a toilet or washroom. (Read Houses, water and energy **Ch 7**)
- You can use it to collect and use excess water.
- It stores more water in the soil and in the compost material, extending the wet season and fully utilising any dry season rains and dry season watering.

SMART IDEA:

To reduce mosquito and pest insect problems: soak a big handful of neem leaves in a bucket of water for two days, pour some liquid, with the neem leaves, into each pit. Repeat every three months. Make sure there is no standing water in the top layer of leaves

DIRECT COMPOSTING ROTATION SYSTEM

Composts can be made on top of existing garden beds or on land where you are going to make garden beds. You can build a moveable frame to hold the compost or simply make a big heap. Use the same layering methods and materials as for making compost in bays. You can turn the compost to speed up the process. A cover for the wet season is important. Spread out the compost when it is ready and there will be enough to cover and fertilise many beds. When the compost is half ready, start new compost on a different bed and continue, so that you have regular compost heaps.



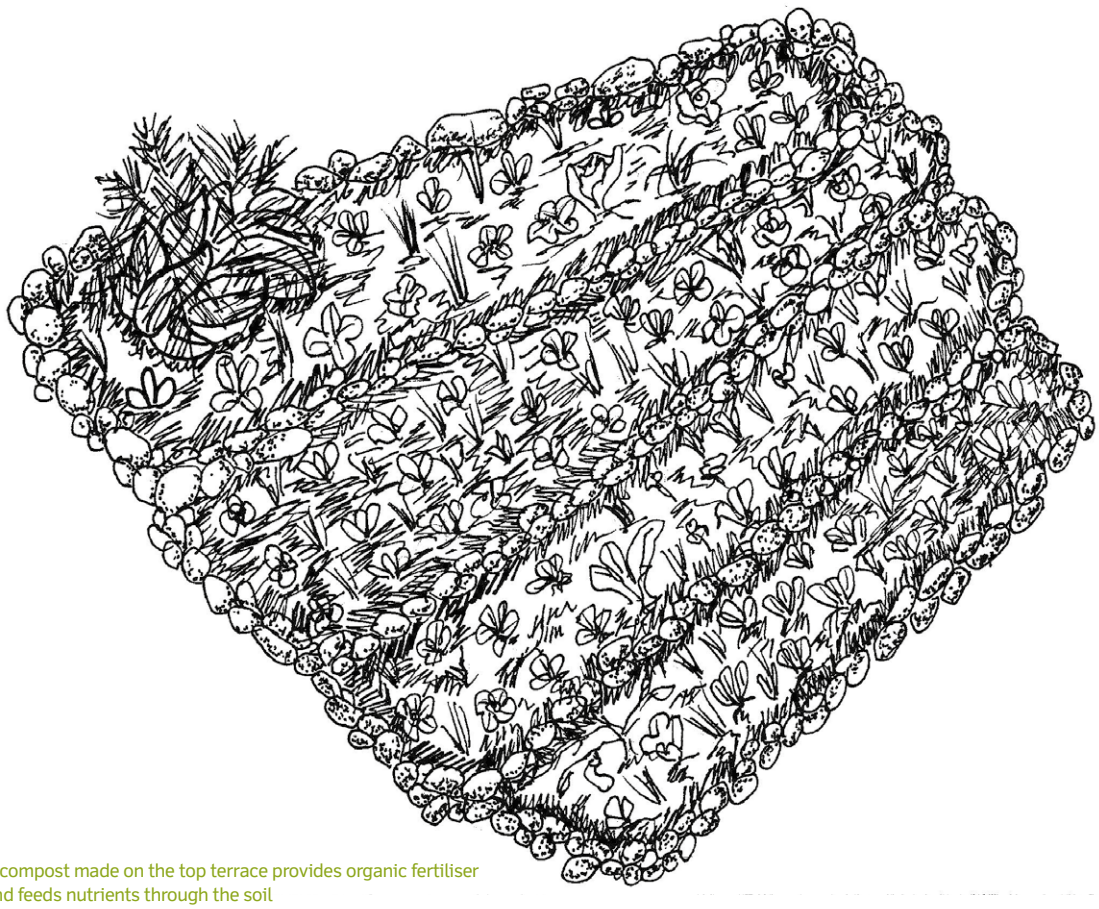
1. Compost on garden bed

2. Garden bed planted with next compost made on different garden bed

There are many benefits from using this system:

- The soil underneath will improve a lot from leached nutrients and increased soil biota.
- Rotating the compost heaps will give your garden beds some occasional rest time and can be part of a crop rotation system.
- You do not need to make separate compost bays, however you still need a compost resources area.

Look in Soil (**Ch 9**) for explanations and pictures of compost and liquid compost making and mulching.



A compost made on the top terrace provides organic fertiliser and feeds nutrients through the soil

GARDEN BEDS WITH FISH PONDS AND PADDIES

Garden beds can also be integrated with small vegetable paddies and fish ponds.

The raised beds are made from the soil dug out to make the paddies or fish ponds. The paddies and fish ponds will collect the run-off water from the raised beds, and in the wet season you can grow water plants, such as taro, water spinach and water cress, and raise fish.

Small paddies for growing vegetables next to raised beds

Water channel from spring to fishpond

You can use the system all year with the paddies becoming vegetable beds in the dry season, and by digging out the soil at the bottom of the fish ponds, you can fertilise the paddies and raised beds. Build trellises for annual vegetables, such as beans, luffas, cucumbers, and squash, over the paddies.

This system works best with a gentle slope, but it can work on other land too. It is good in wetland areas, creating high raised beds from digging paddies or fish ponds that allow good drainage. It is especially good for wet tropical climates, areas where flooding regularly occurs or where there is a regular, large water supply.

Sometimes you can use the clay fish ponds seasonally, raising fish in the wet season and growing vegetables in them in the dry season. The soil at the bottom of the ponds will be very rich. You can grow vegetables around the edge of permanent fish ponds.

These designs for gardens are examples.

You can use them or put different ideas together to make your own, or create a completely new garden. Every garden is different: your garden can be as big or small as your land allows. Importantly, the garden should fit with the natural pattern of the land and with your needs. If this happens, every garden WILL be different and will be the most appropriate for you!

GARDEN MAINTENANCE

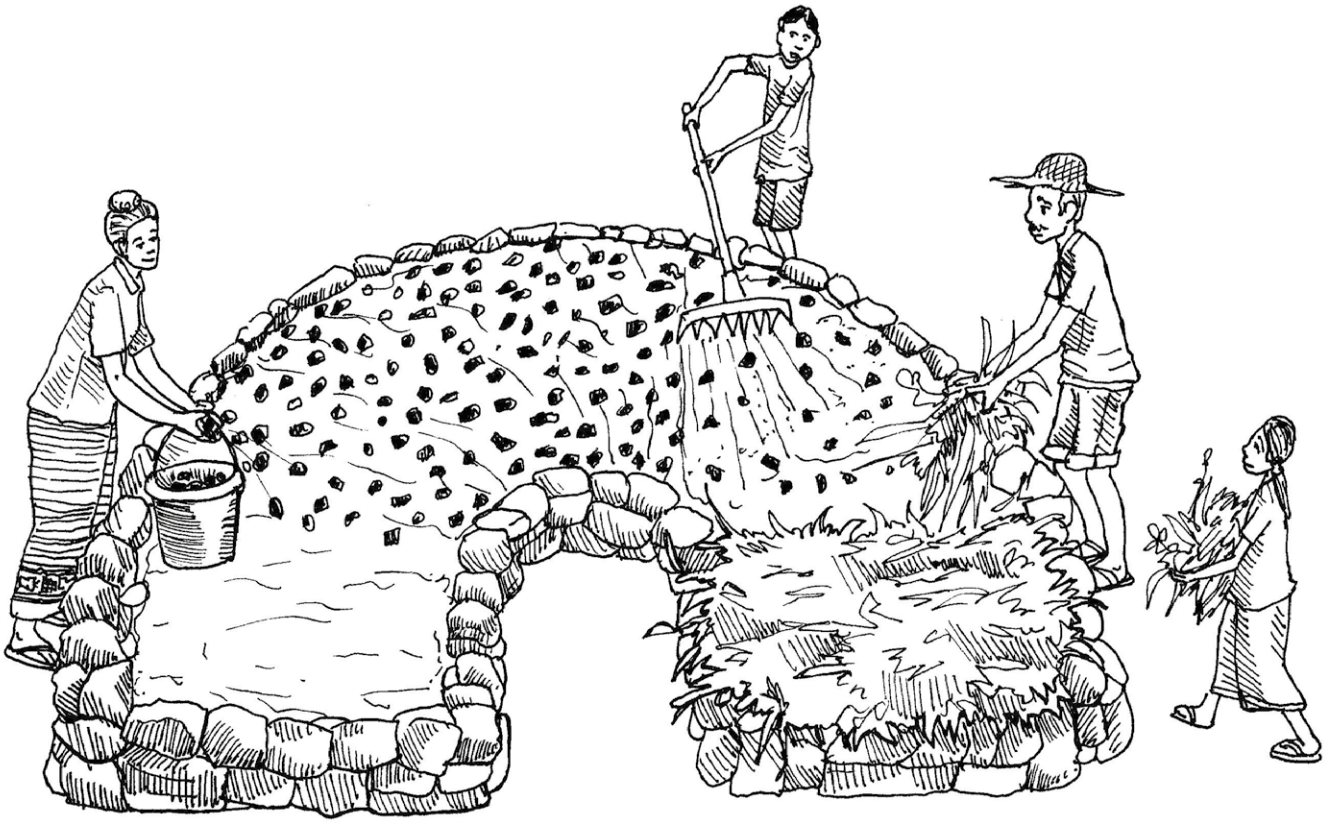
Adding plant food

Garden beds should be covered with compost or aged and dried animal manures at least two weeks before planting.

This is very important as the nutrients will then be ready for when you plant the seeds or seedlings. (Do not use bird manure, as it is too strong to put on straight the garden: it should be composted first.)

Activated charcoal (biochar) is an excellent soil improver and can be added as well. You only need to add biochar once or twice to last for many years. Rock dust is the same and adds minerals. Spread two big handfuls of biochar per square metre and a big handful of rock dust, and lightly dig it in.

You can lightly turn the fertiliser into the soil if nothing has been planted, or just leave it on top. When you have planted the vegetables or trees, add more compost one week or more after planting, but put it on top of the soil. Disturb the plant roots as little as possible.

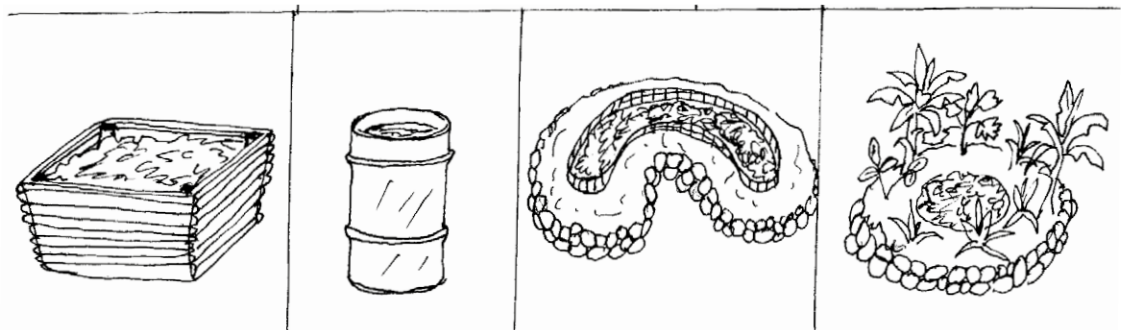


Adding biochar and mulch

After composting it is vital to add a thick layer of mulch on top of the soil. Mulching the garden provides many benefits, saves a lot of water, and is ESSENTIAL for long-term soil improvement. If you have access to seaweed, wash it in fresh water and use it as mulch to add lots of extra nutrients.

Add liquid compost every two weeks to a month, but be sure to mix it properly with water.

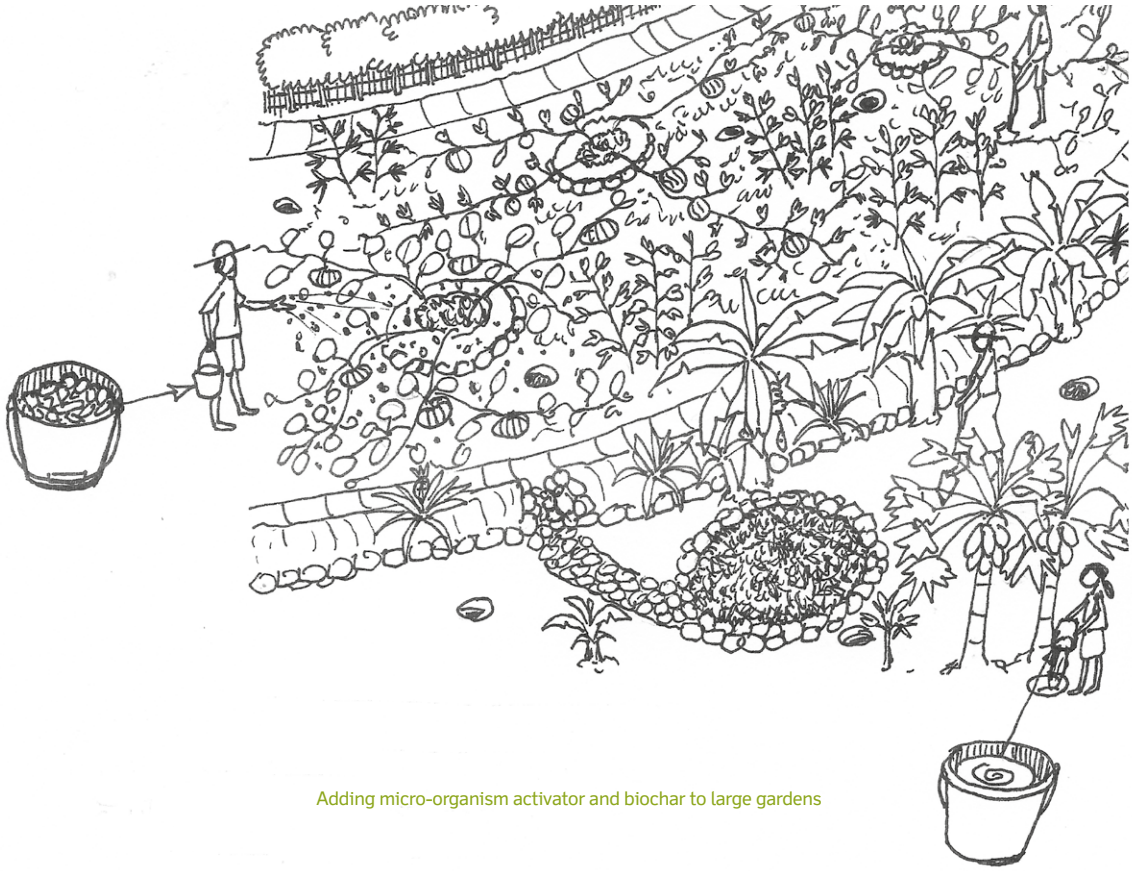
There are many different ways to make and use compost and liquid compost. It is up to you to decide which method is best for your situation.



Different composting methods

Use micro-organism activators to accelerate soil improvement and boost other techniques. They include good bacteria, fungi and nutrients to improve soil quality, soil structure, and nutrient availability, and multiply, spreading good bacteria and fungi through your soil. You do not need to cover the whole garden but dig in a handful of micro-organism activator every metre using a zigzag pattern. You MUST mulch the soil so that the bacteria have food and your soil does not dry out. Use them especially when:

- Compost is in short supply
- Improving a large area quickly
- Fixing old dead soil



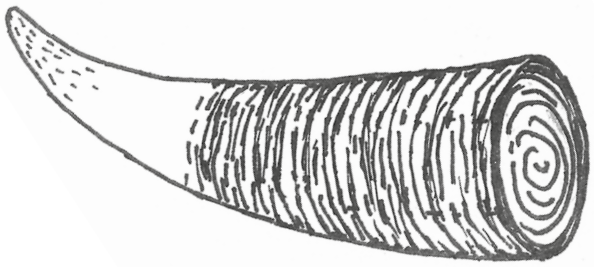
Adding micro-organism activator and biochar to large gardens

An important method for feeding plants is to use green manures as part of crop rotation. This adds lots of organic matter and fresh nutrients.

Read Soils (**Ch 9**) for how to make and use compost, liquid compost, activated charcoal (biochar), micro-organism activators, rock dust, and green manures.

Adding mulch to gardens

Bio-dynamics – in many tropical countries and regions, especially where cow manure is available, biodynamic techniques are being used and providing good results. There is a lot of information on the internet, and if there are local farms or demonstration/education sites near you it is good to learn about these techniques. See Soils (**Ch 9**) and the reference chapter.



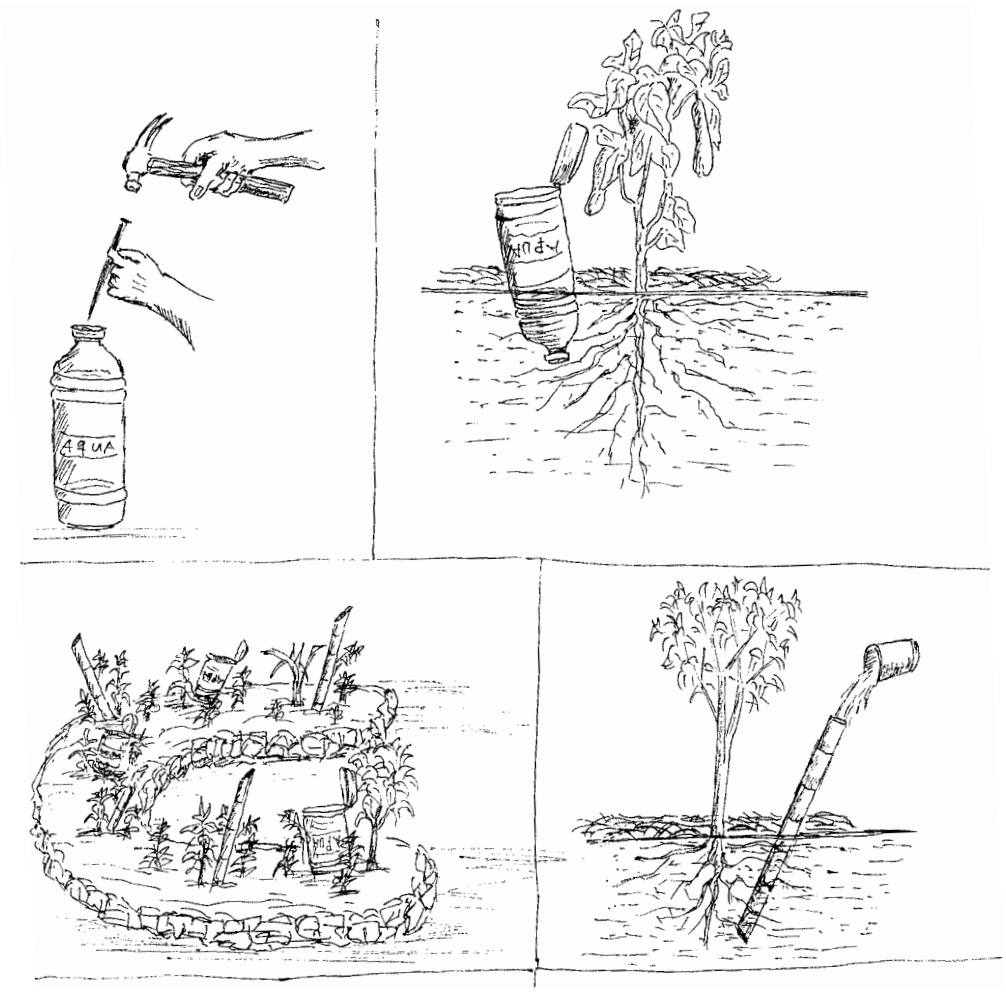
Cow horn used for preparing biodynamic compost

DANGER: do not burn weeds or crops when clearing land for the next crop!!

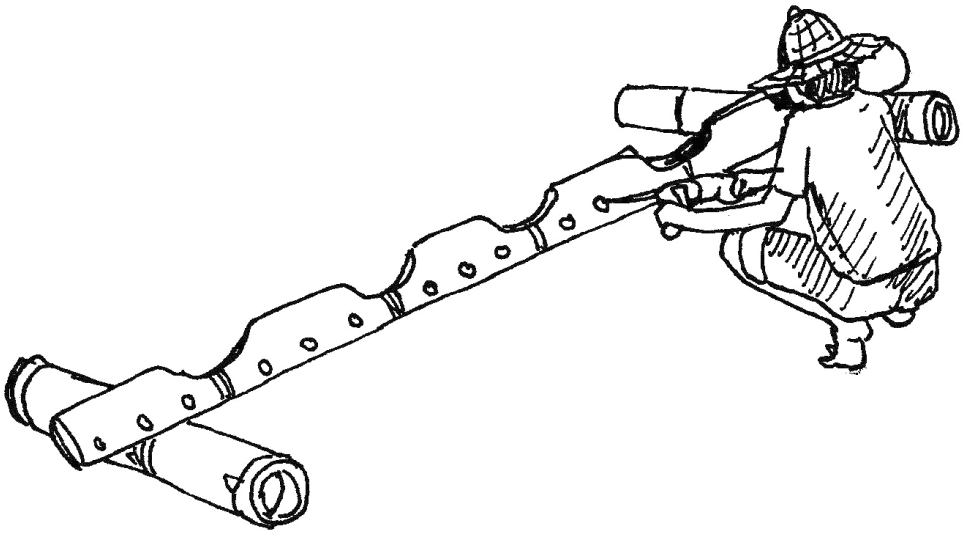
Burning wastes a lot more nutrients than it creates. In tropical climates a lot of nutrients are stored in plants and this is lost with every burning. If you want to add some ash, burn some bamboo poles and spread this ash over the garden beds. Weeds and old crops are excellent for compost material, animal food or mulch, and all the nutrients are recycled with these methods. Also, burning kills all of the good bacteria and fungi that improve your soil.

WATER-SAVING TECHNIQUES

1. **First, and most importantly, always water very early in the morning or late afternoon.** Early morning is better because watering in the late afternoon and at night can promote fungus problems. In the middle of the day the sun causes a lot of water to evaporate into the air and very little water enters the soil. Also, plants look like they are wilting, but they are just closing down to save water. They cannot take up much water during this time, therefore the water is wasted. Following this advice greatly reduces water use for each bed.
2. **Garden borders help a lot to hold more water in the soil.** Use rocks, bamboo, wood, etc.
3. **Mulching has many benefits.** One of the most important benefits is that it protects the soil from the sun and prevents evaporation. This reduces the soil temperature and the amount of water needed.
4. **Windbreaks around the garden save a lot of water.** Wind makes plant leaves dry out and lose water so plants need to use more water from the ground. This is most important for young plants and trees.
5. **Watering pipes.** Plastic water bottles are everywhere and burning them causes bad health problems and pollution. A good way to reuse them is to make watering containers that slowly water deep in the soil. Bamboo can also be used and is more effective, especially for fruit trees. The benefits of deep watering are:
   - Evaporation is reduced because water is released into, not on top of, the soil.
   - Water concentrates at the roots of each plant.
   - It uses a lot less water.
   - The containers can also be used to feed liquid compost to plants.



6. **Garden beds that are dug out** rather than raised will save a lot of water, especially in very dry areas.
7. **Bamboo irrigation.** Another good water-saving idea is to make bamboo irrigation pipes for the garden beds. They save time and effort too. Cut the poles in half and knock out the nodes inside. Drill small holes in the poles 20cm apart, at an angle of 20 to 30 degrees from the bottom (illustration) to allow water to flow easily to the far end. Place the bamboo on forked poles, 5 to 10cm from the ground to prevent the holes from clogging up, about half a metre apart.



Making above ground bamboo irrigation

Using above ground bamboo irrigation

Weed control

Weeds reduce production in your garden by stealing water, nutrients, and sunlight.

However, they are also often a useful indicator of your soil conditions and are a valuable resource—a great source of mulch, food for animals, and important compost and liquid compost material. Weeds with deep roots collect and store valuable minerals and are especially good for compost or animal food. Some weeds are traditional medicines and even food sources for people, especially during a drought. You should manage and control weeds, especially running grasses that spread underground, and bulb weeds, but you should also see them as a benefit rather than a problem. Reusing weeds reduces the need to bring in compost materials and helps keep your soil healthy. Be careful that some weeds are not good to feed to animals: use these for mulch and compost.

Cover crops are excellent for weed control, e.g. velvet beans, cowpeas, sweet potatoes, and kalopo are all very useful. In the wet season, plant them thickly to cover the ground and compete successfully with the weeds. They suppress most weeds and even reduce problem weeds, making it easier to remove them. Cover crops also improve the soil, add nitrogen if they are legumes, and provide mulch and compost material.

1. It's weed burning time!

2. No! What's he doing?

3. Don't waste your weeds, use them!

PROBLEM WEEDS

Running grasses that spread underground or weeds that grow from bulbs need special management. It is best to take time to dig them out completely.

These include problem weeds like Kikuyu grass (Pennisetum clandestinum), nut grass (Cyperus rotundus) and couch grass (Elymus repens). Each tropical region has its own problem weeds as well.

Nut grass, kykuyu and couch grass

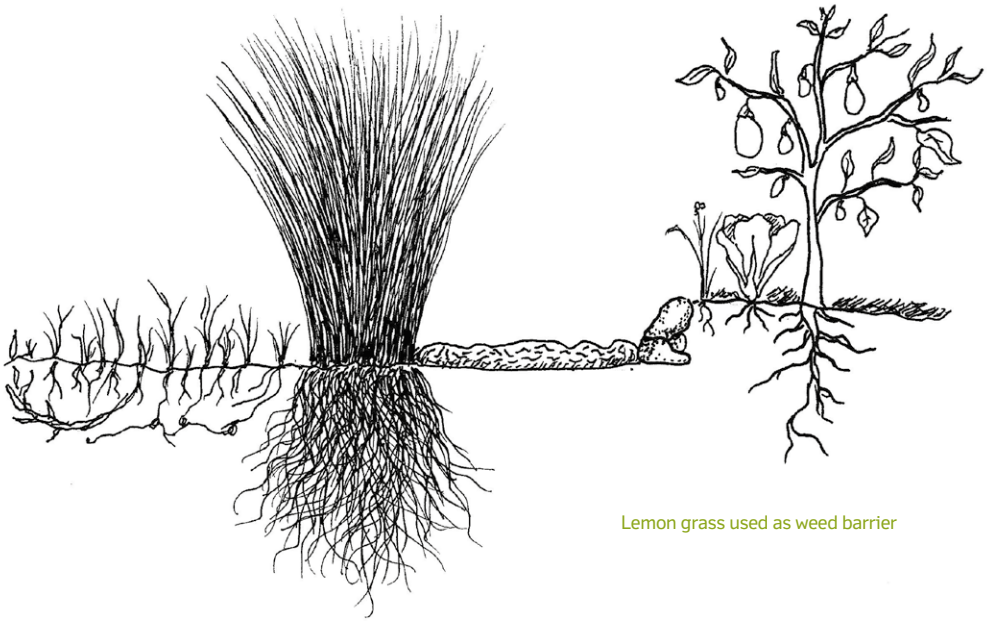
For running grasses, dig over the soil and check carefully to remove every piece. Then water the cleared ground very well. This will force new growth from any pieces that remain, so you can see and remove them in the following few weeks. Dry these weeds out completely, and use them as mulch, animal food or in compost systems, or add them to very strong liquid compost. In the wet season they do not usually dry out properly so use them as animal feed only.

Try to dig up and remove every bulb weed. Sometimes it is best to sift the soil if there are many. Dry the bulbs out completely, then burn them and use the ash on the garden or in compost.

A long-term option is to cook the weeds by covering the ground with black plastic sheets. This takes a minimum of three months, it kills the weeds and their bulbs and seeds but will also remove most good soil bacteria and fungi.

Make a 'weed barrier' around the outside of the garden to stop running grasses or bulb weeds from growing into the garden beds. The weed barrier can be:

- A path around the edge that is kept free of weeds: this allows you to monitor and prevent weed problems before they enter your garden beds.
- A small but thick living fence that will prevent running grasses from entering the garden: lemon grass, vetiver grass, pigeon peas, other small legumes, sweet leaf, cassava, and taro can all be used, as well as any plant that can make a thick fence and has a large root system.

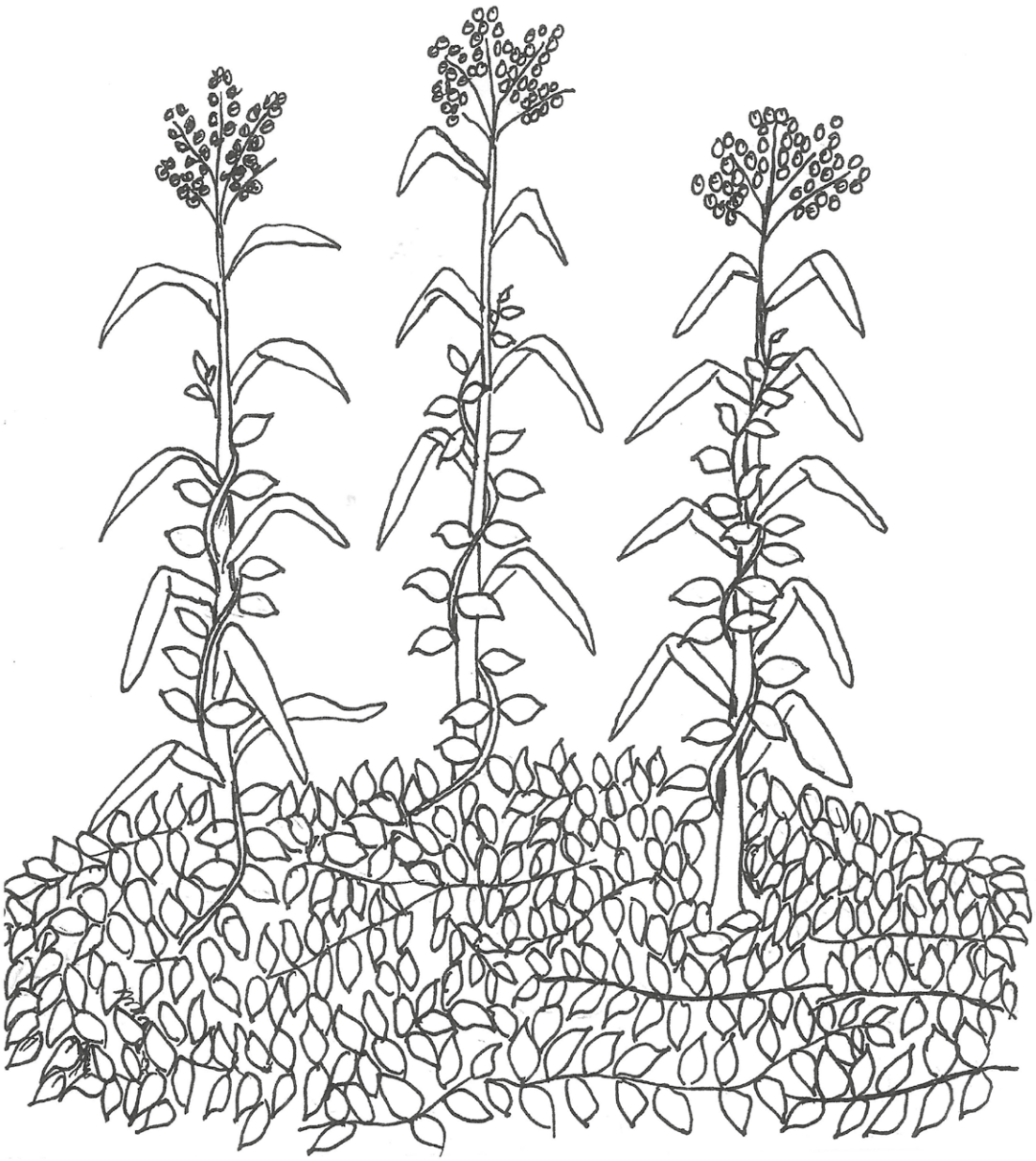


Lemon grass used as weed barrier

Natural herbicides for problem weeds:

Vinegar is a natural herbicide and can be used to help with these sorts of weeds. It is recommended to dig the weeds out first, and then only use vinegar as a follow up on new growth. It kills the weeds by direct contact. Fill a spray bottle, add a teaspoon of dishwashing detergent to improve results, and directly spray the new shoots. BE CAREFUL: it should not be over used or misused as it can affect soil PH and kill other plants if you accidentally spray them too. Vinegar does not work by itself; it must be a part of a weed management strategy. It will kill other weeds too, so the techniques below are much better for your garden.

Molasses can be used to kill nut grass. Add a cup to 4 litres of water and spray on the affected area. It will probably take three sprays over a month to affect it and eventually the nut grass dies off. Molasses is harmless to your soil and even helps good bacteria to multiply.

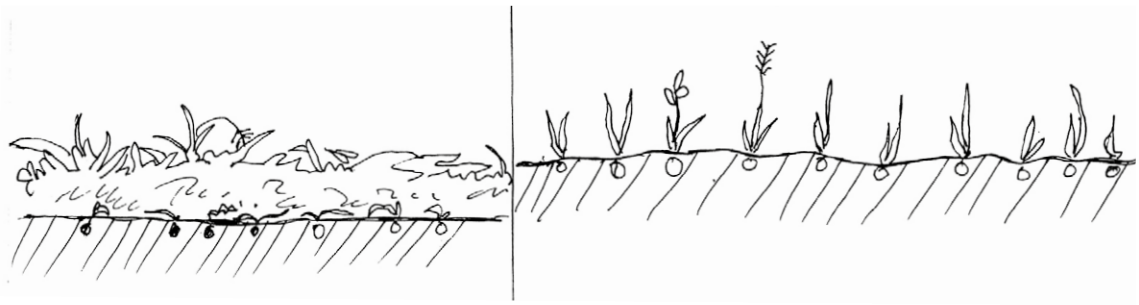


Beans as living mulch

OTHER WEEDS

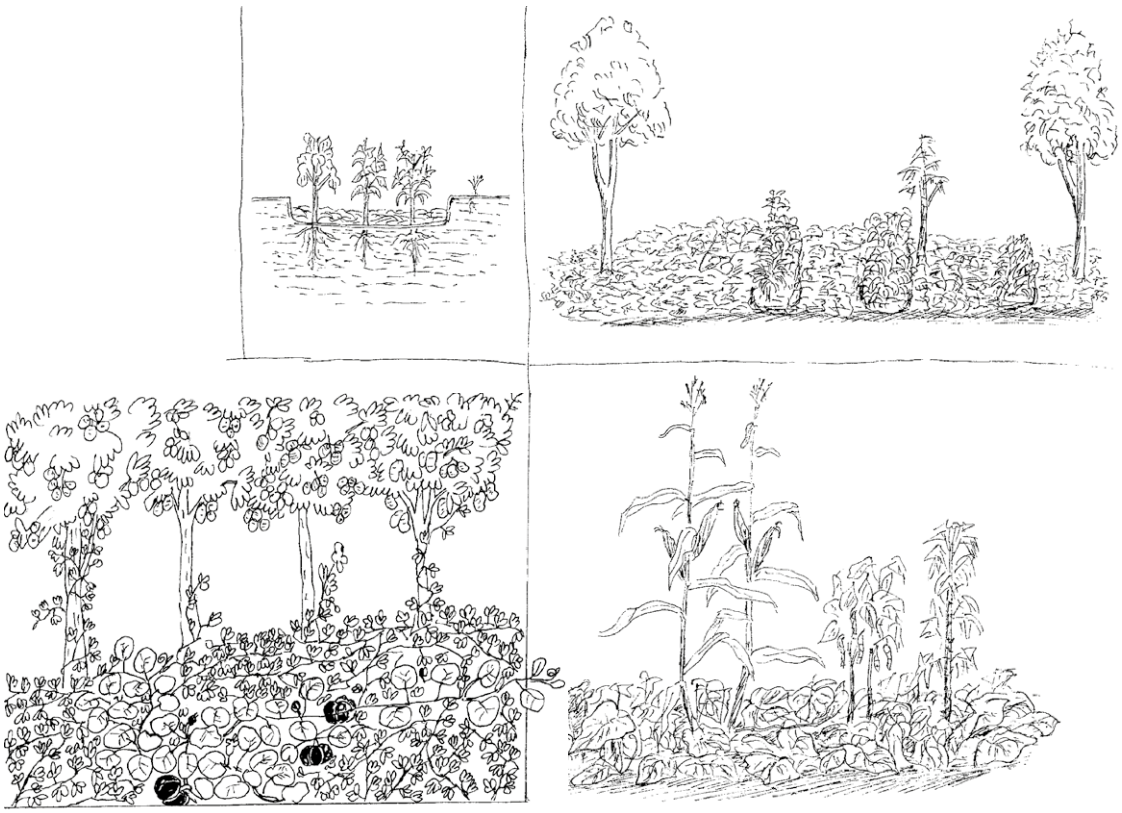
Natural methods for controlling weeds that are spread by seeds include:

1. Mulching the vegetable gardens continuously greatly reduces the amount of weeds. This is because mulching the ground stops light reaching the soil surface. Weed seeds grow towards the sunlight because they need it to produce food. Most weeds die before they reach the light. The mulch layer needs to be at least 6cm thick to be most effective, and even then it does not fully control some running grasses and bulb weeds. Try not to use mulch that contains a lot of weed seeds because this can spread weeds. If you use running grasses as mulch, make sure that they are completely dry to stop them from growing again.



Thick mulch prevents many weeds from growing

2. Minimise competition. Plant crops with just enough space for each one to grow to full size, so weeds will struggle to grow.
3. Plant ground-covering vegetables, such as pumpkins, beans, luffa, and yams under cassava, corn, and other large crops to reduce weeds. The same technique can be used under fruit trees or other tree crops. Plant the pumpkins, yams, luffa, and sweet potatoes in mounds on flat land or in swales on sloped land.



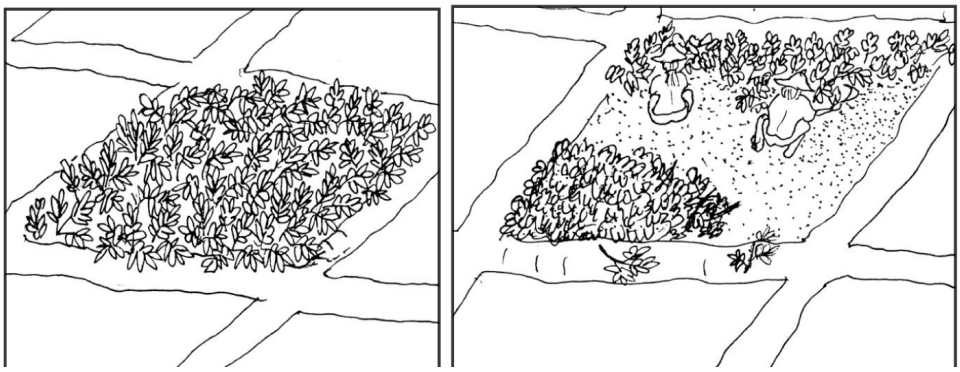
Ground covering vegetables reduce weed growth

4. Every time soil is turned over weed seeds are disturbed and are more likely to grow. Therefore, if you turn over the soil less, fewer weeds grow.
5. Look in the Animals chapter (**Ch 17**) for how to make and use an animal tractor. They can be used after harvesting and are a very good way to remove weeds and their seeds, and fertilise the ground at the same time.
6. Any weeds that do grow should be removed before they produce seeds. By doing this you will slowly reduce the number of weeds. If you remove weeds when they are young, you will not damage the vegetable roots. Steps 1, 2, 3, 4, and 5 will all reduce the amount of hand weeding needed.

You should carefully remove weeds that have already seeded, so seeds do not drop. Do not use them as mulch or in compost: feed these to animals or put them in banana pits or liquid compost.

GROW YOUR OWN WEEDS

Productive plants as weeds: continuously collecting and spreading seeds and cuttings of useful plants that grow easily create new weed problems. The useful plants become weeds! Some types of vegetables, fruit, animal food, legume-cover crops grow quickly and spread easily. This method helps to provide more food, especially for animals, and is an effective way of controlling problem weeds. The plants that can be used in this way will change from region to region, and in each place people know what grows fastest and spreads most easily.



Green manure weed crops in rice paddies

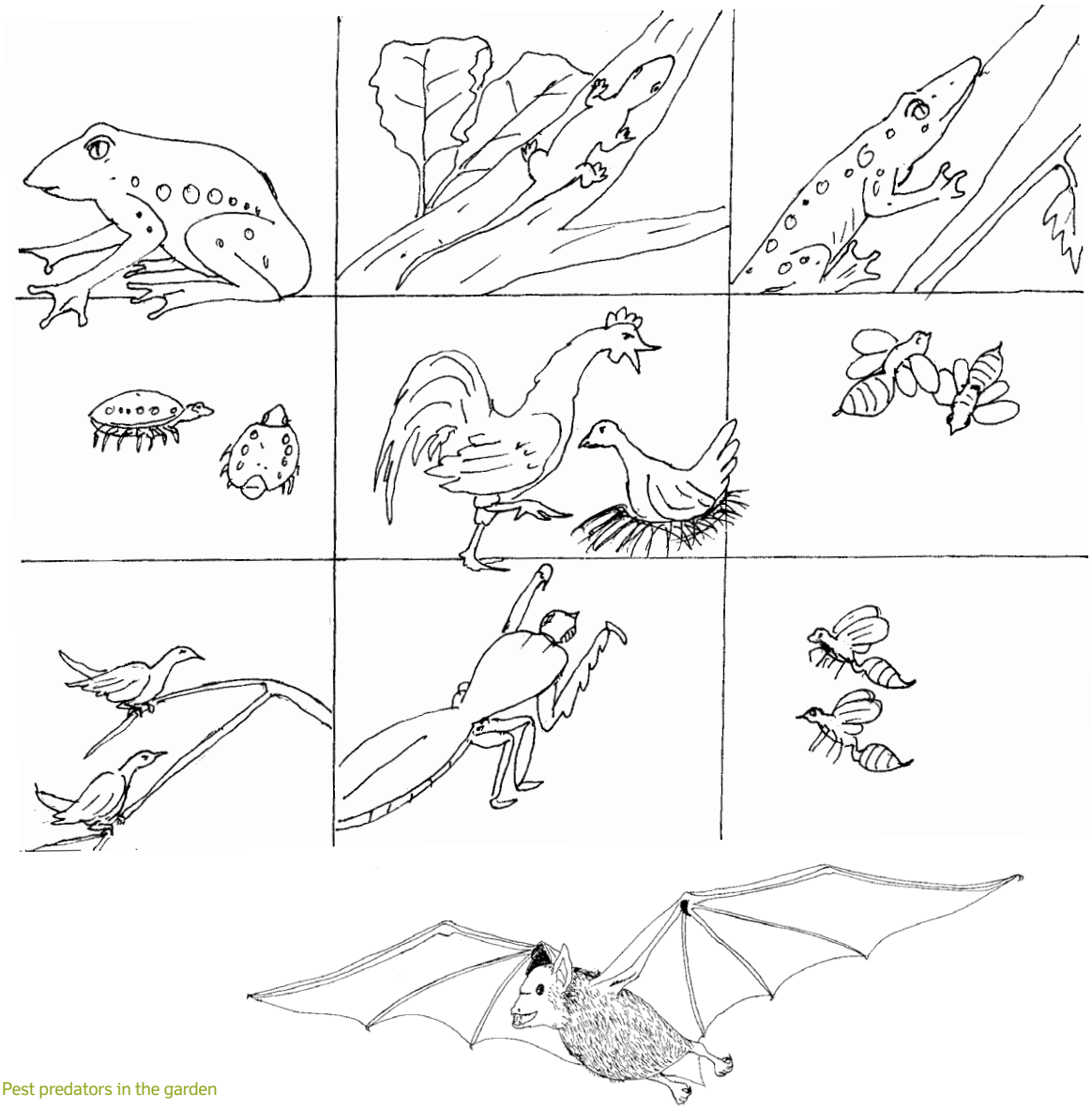
Weeds as green manure: allow a crop of weeds to grow then dig them back into the ground before they flower. This reduces weed seeds, improves the soil, and provides important nutrients. CAREFUL: do not use running grasses or bulb weeds.

Weeds as indicators: often weeds that grow are a relation of productive plants. If a particular weed grows very well, it can be an indicator that related plants also grow well, e.g Solanaceae family: nightshade, cape gooseberries, soda apple (Solanum viarum), and wild tobacco are related to eggplants, tomatoes, chilies, capsicums, and potatoes. Dock (Rumex spp) grows at higher altitudes in the tropics and is an indicator of good soil moisture. Silver beet and beetroot like growing where dock grows.

PEST AND DISEASE CONTROL

Pest and disease control in the garden is not just about removing the pest problem. Problems are a sign that the system is not in balance, and rebalancing the system is the best solution.

To control pests in a sustainable method involves using many different techniques that result in rarely having to use pesticides or fungicides at all, such as improving soil quality, encouraging pest predators, good garden management, and using baits and traps.



Pest predators in the garden

For example, using compost does not only improve your soil and increase production. It also helps plants to be more resistant to pest and disease attack. It adds good bacteria and fungi that reduce the amount of problem bacteria and fungi in your soil.

If pesticides or fungicides are still needed, natural recipes from local plants should be used, not chemical pesticides or fungicides.

The Integrated pest management (IPM) chapter (**Ch 14**) in this guidebook gives a step by step method for naturally controlling pests and other problems, and different recipes for natural pesticides and fungicides.

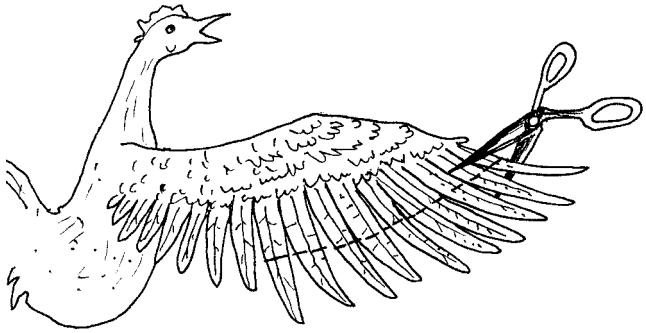
Chicken control

Chickens can be a big problem in family gardens. Often they are the neighbour's chickens; therefore solutions need to include community understanding about chicken management.

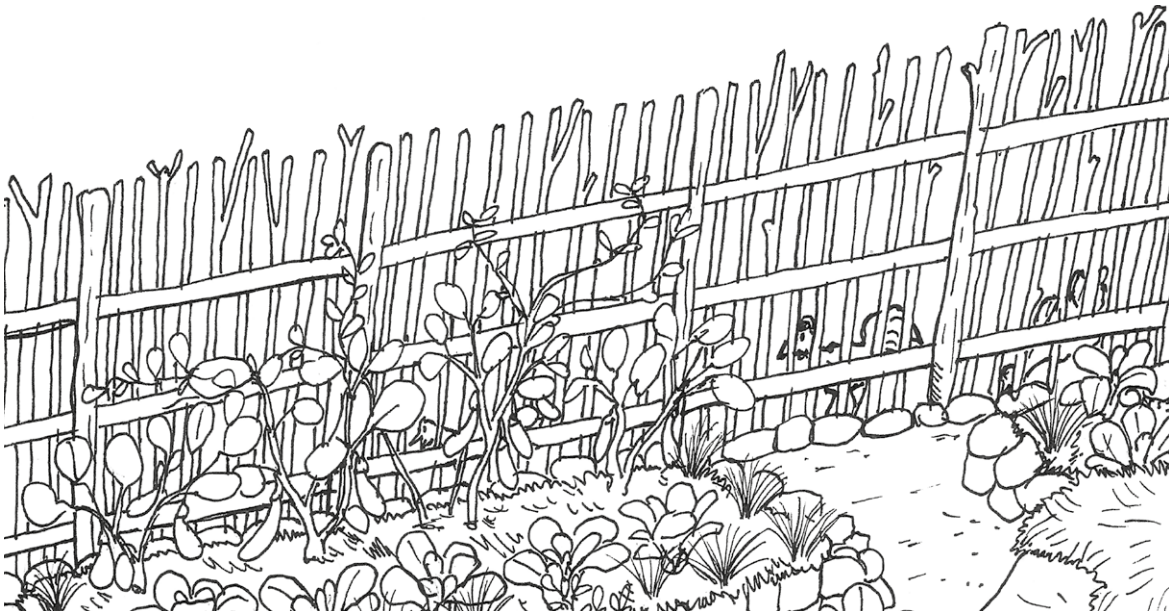
Solutions include:

- Keep chickens in a permanent house and yard. This includes clipping their wings to stop them flying if necessary.
- Keep chickens out of the garden by building a high fence around it. Sometimes chickens can still fly in so clipping their wings may still be necessary.
- Protect garden beds using coconut palm and other split-palm leaves, thin branches and upright sticks in the soil, loosely woven split bamboo panels (10cm apart), and other things that prevent chickens from scratching.
- Have community agreement on chicken management including how to prevent damage from wild chickens and what penalties to apply when they destroy garden beds.

Chicken houses and yards are the best method. Read Animals (**Ch 17**) about chicken yards, clipping wings, and more.



Clipping chicken wings

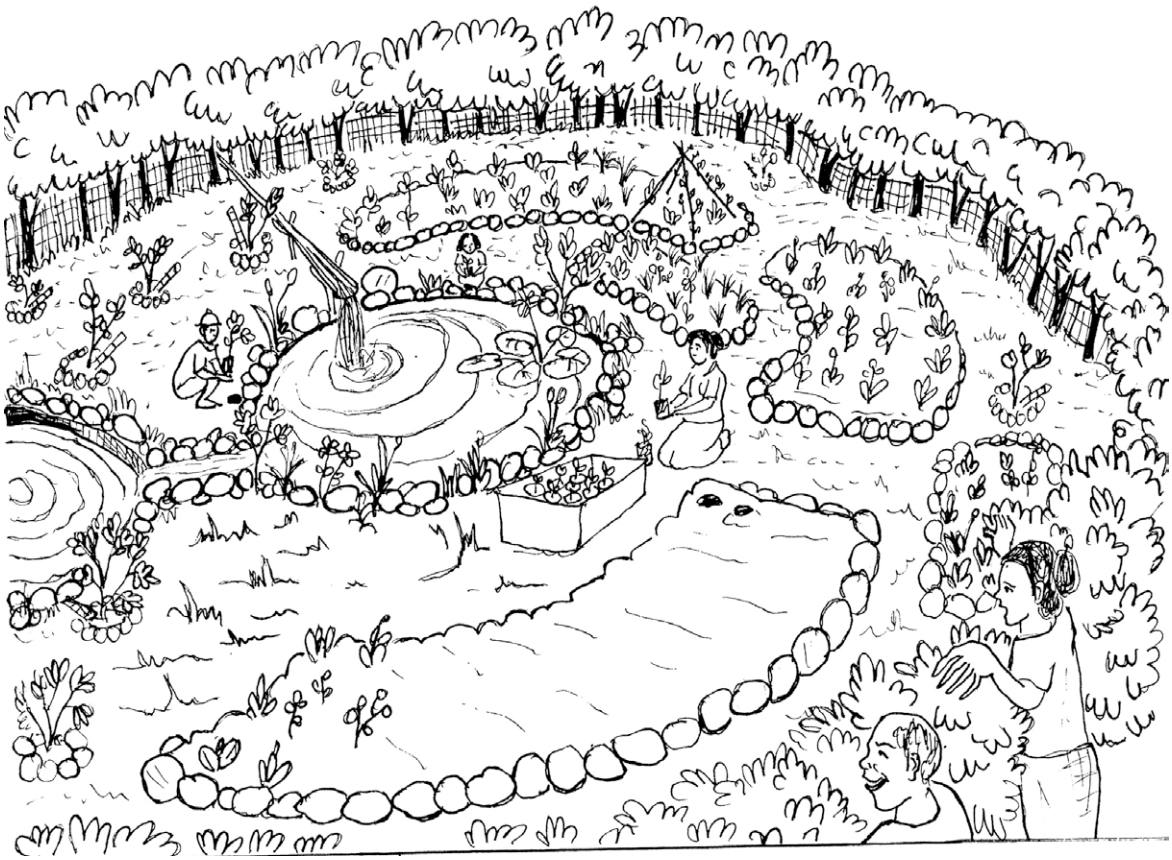


Preventing chickens scratching garden beds

CLIMATE CONTROL

There are many techniques that will moderate the climate in your garden and create a more productive space for growing food:

- Create shade over some garden beds during the hottest time of year before the wet season. Read 'Integrated garden design' earlier in this chapter for more details.
- Have ponds to moderate temperatures.
- Plant small trees and shrubs around the edge to cool and reduce hot winds.
- A few legume trees in the garden create partial shade for some plants (and people!).
- Mulched paths and garden beds keep the ground cooler.



Ponds and living fences help create a better climate for gardens

PLANTING METHODS AND PLANTING TIMES

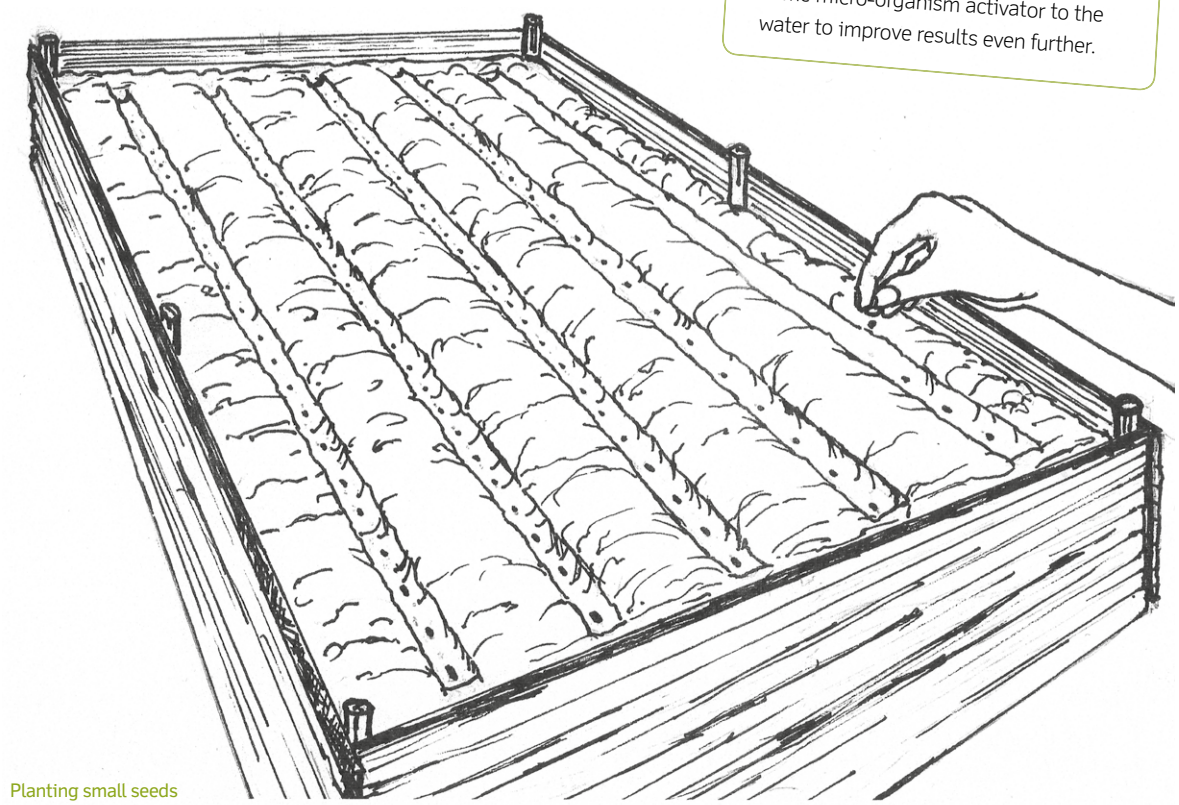
Seed planting ideas

Read Plant nurseries (**Ch 12**) for detailed seed planting techniques.

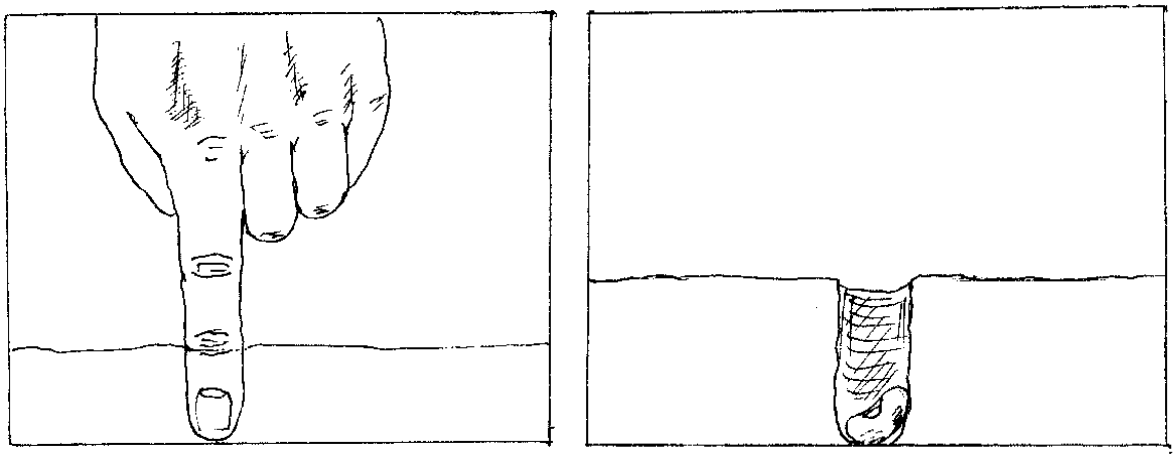
For gardens, plant small seeds about 0.5 to 1cm deep: planting into furrows is best. Large seeds (any seed bigger than a pea) should be planted 2cm deep. The soil needs to be watered every day.

SMART IDEA:

Most seeds should be soaked in water overnight before planting: 18 hours prior is best. This increases the amount of seeds that grow, and the seedlings grow faster. It also ensures better results in a changing climate. Add some micro-organism activator to the water to improve results even further.



Planting small seeds



Planting large seeds

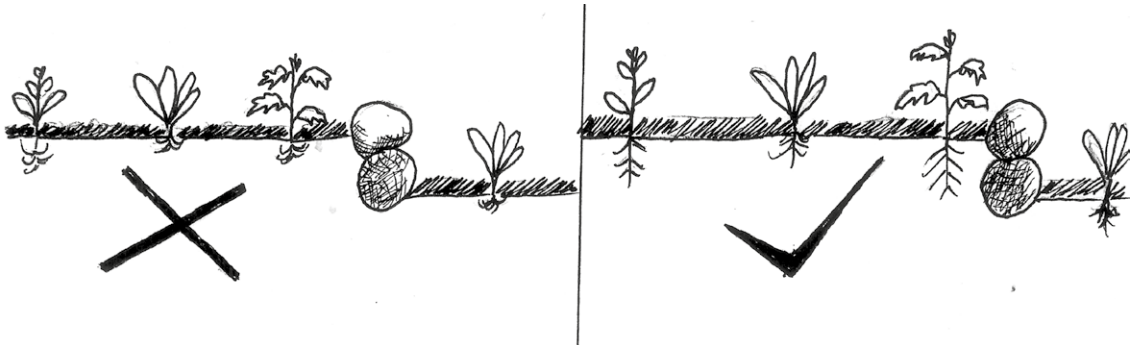
SEEDLING TRANSPLANTING IDEAS

The following ideas reduce damage caused to plants and plant roots when planting. Plants are alive and react to damage or mistreatment in the same way as humans!!! Any damage slows plant growth and reduces the final harvest.

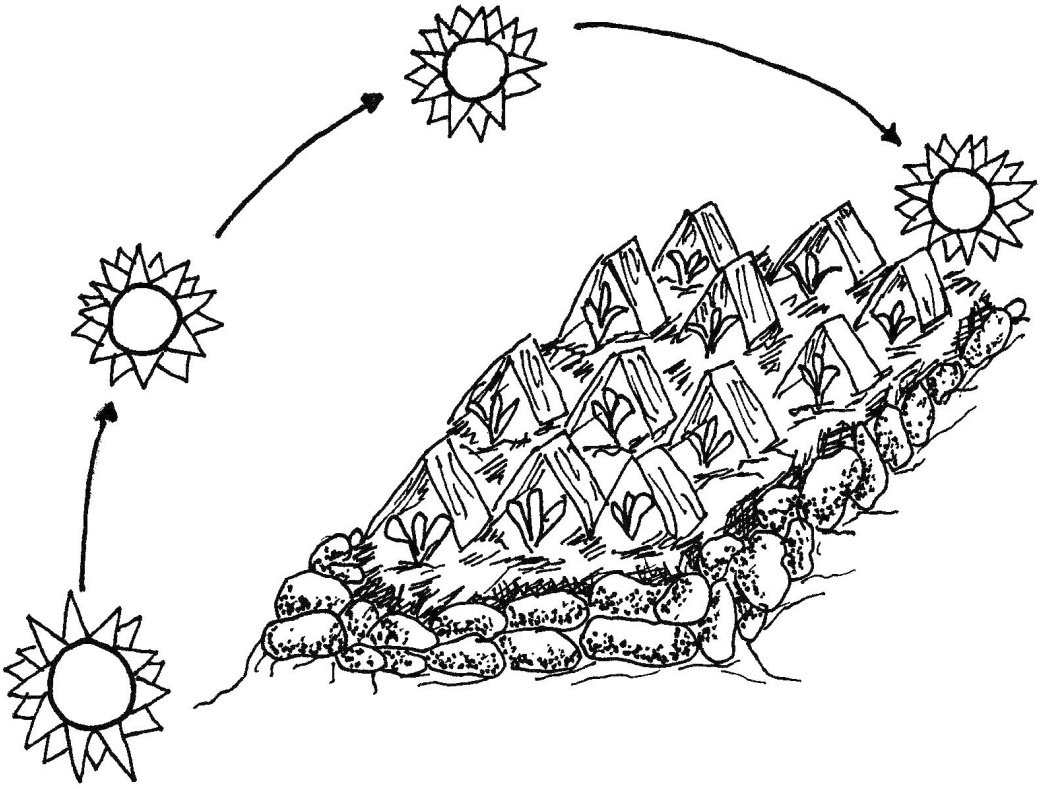
Planting seedlings late afternoon

- Increase the sunlight for seedling pots for a week before planting so the seedlings get used to the extra sunlight in the garden. This technique is called 'hardening' the seedlings: it reduces stress and leaf burning from the sun when you plant them.
- Always water before and after planting seedlings into the ground.

- Be very careful when handling plant roots. Do not expose the roots to sunlight, try not to break any, and hold the plant by the stem, **not** the roots.
- Make sure that the plant roots are always pointing down when planted. This is very important.



- Plant seedlings in the late afternoon to avoid the hot sun during the day.
- In the hottest times of the year cover seedlings with banana stem/leaves or coconut leaves for two to three days to protect them from the sun. Create upside down 'V-shaped' covers with the leaves, and place them facing north to south so that it lets in the morning and afternoon sun.



Seedling protection allowing early morning and late afternoon sun

Succession plantings

This means that many small plantings over time are better than planting all your garden beds at once.

By planting three crops of the same vegetable at different times you will get three harvests. Therefore, harvests are smaller, but they provide food continually for families and for sale. Food storage is less of a problem, less food gets wasted or goes rotten. It also reduces the risk of crop failure.

Plan ahead: first plant seeds two weeks to a month apart, and prepare the garden beds when they are needed. Different types of the same vegetable can take different lengths of time to grow. If you plant different types, you can harvest at different times.

Using different plant growth times

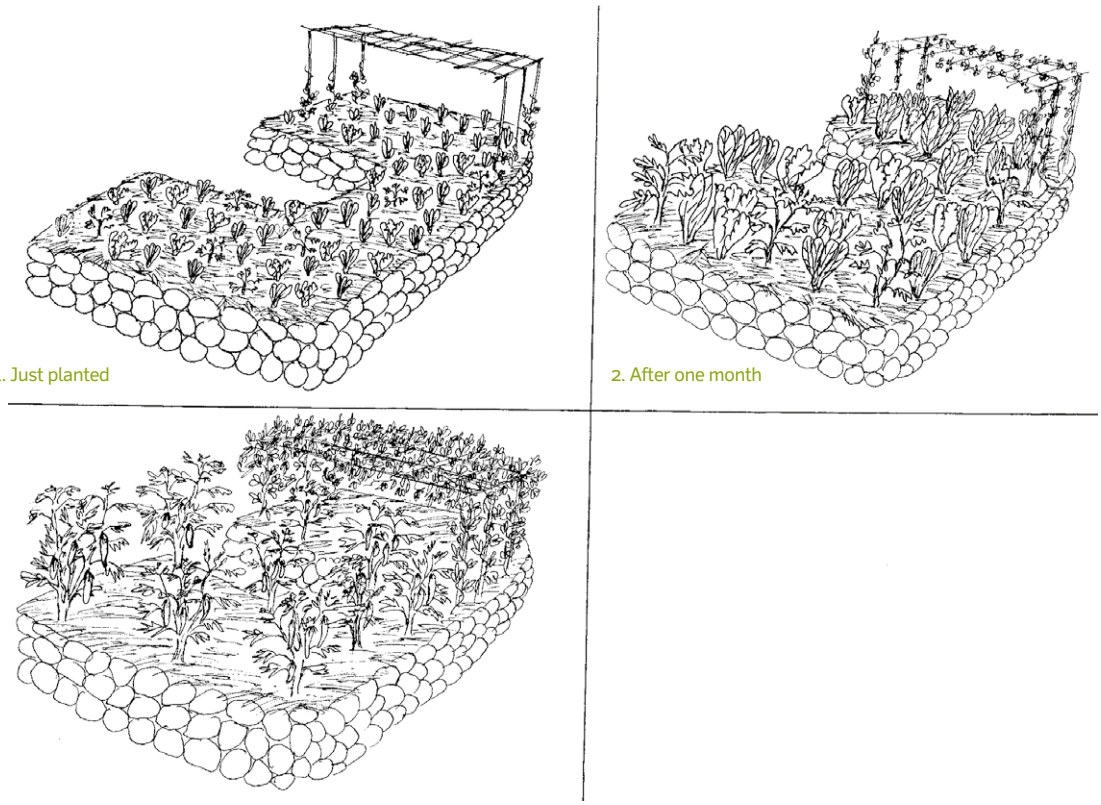
Each vegetable has a different length of time to grow and produce its crop.

You can use this knowledge to increase production in each garden bed.

- Lettuces, radishes, and green-leaf vegetables grow fast and produce their crops in one to two months.
- Eggplants, chilies, cabbages, capsicums, tomatoes, beans, and other vegetables can take three months or more to produce their crops.

Plant the slower growing vegetables the same distance apart as usual, so that when they are fully grown they fill the garden bed. Plant the fast growing vegetables in the spaces between. If you plant them at the same time, the lettuces and green vegetables will need harvesting first before the other vegetables have grown large. The long-term vegetables will then grow to their full size and start producing their crops.

Be very careful to minimise root disturbance of the long-term crop when harvesting the short-term crop.



1. Just planted

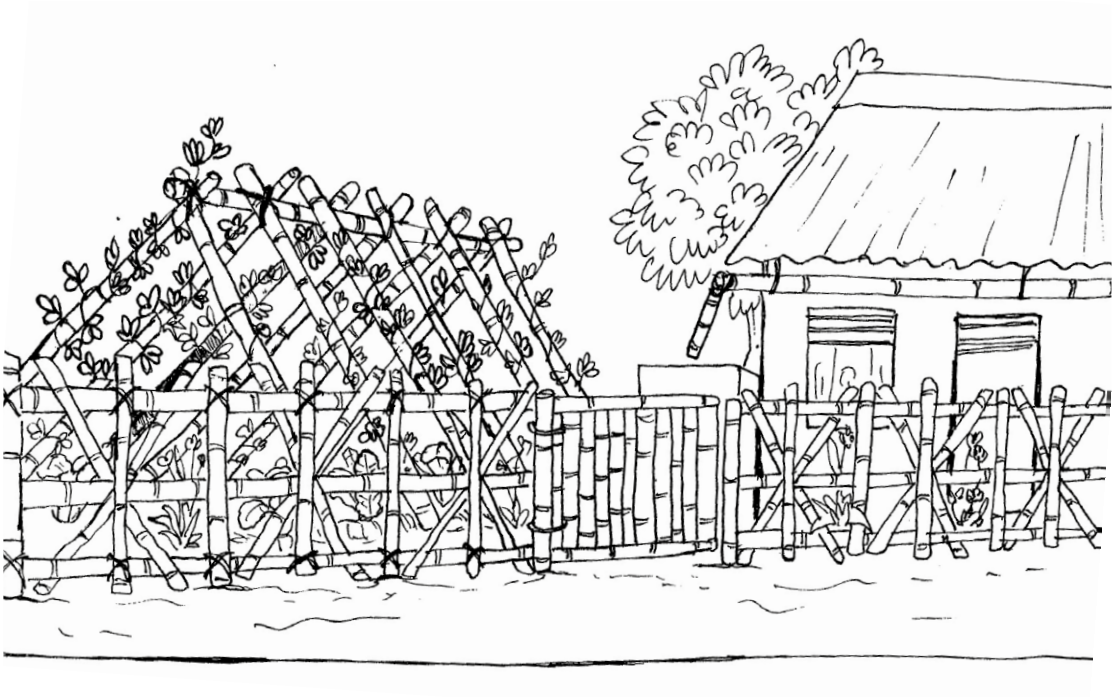
2. After one month

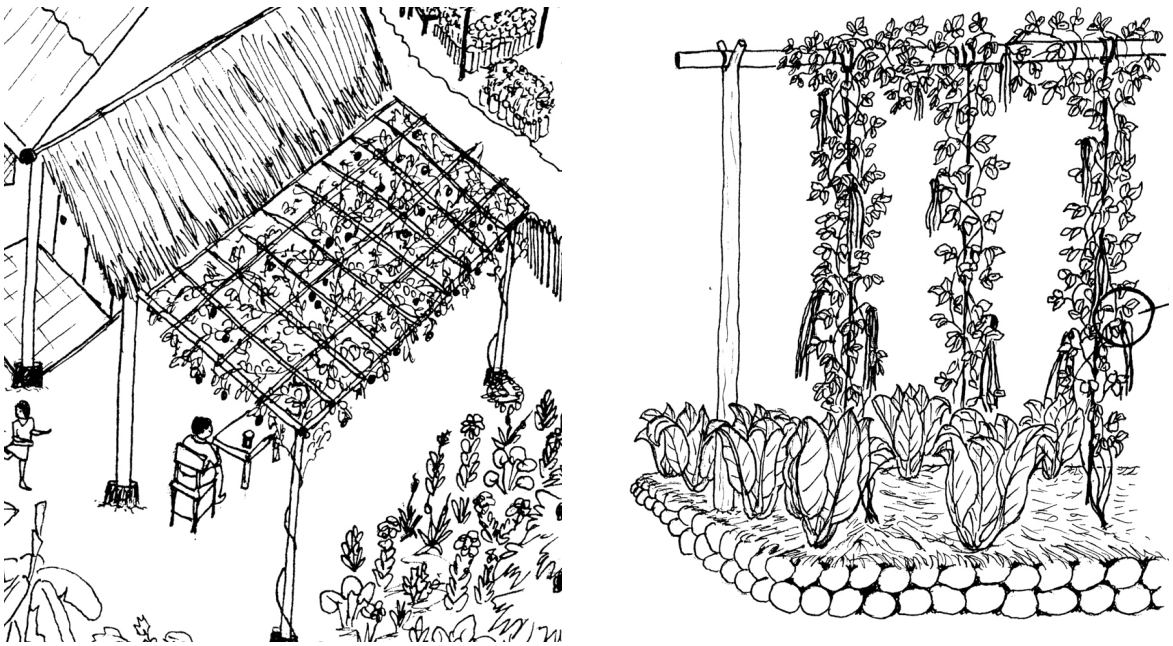
3. After two months

Using different plant heights

Plants that grow to different heights can be grown together to increase the amount of production from each garden bed. You need to take care not to shade the smaller plants too much. Observe the sun direction.

Trellising also increases production. You can use bamboo, wooden poles, old plastic irrigation pipes, metal stakes and wire, living fences, fruit trees, and even corn stalks for trellising. Use your available resources and your imagination!.





Different trellising examples

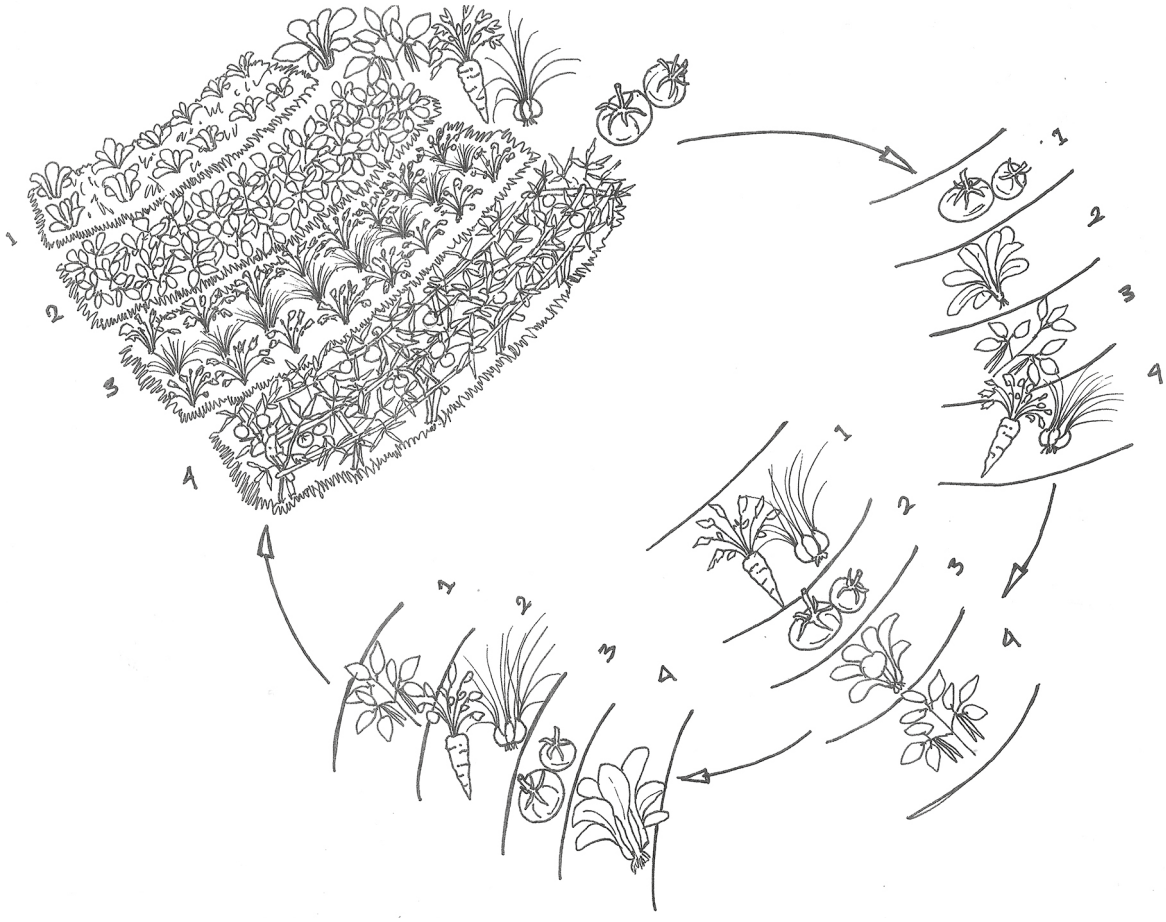
Crop rotation

Crop rotation helps to balance the amount of nutrients taken from a garden bed. Different plants take different amounts of nutrients. Crop rotation is also very important to reduce pest and disease problems, as well as fungus diseases in the soil that attack plant roots.

A good method is never to grow the same vegetable in the same bed twice in a row. All beans can be considered as one type of vegetable. Tomatoes, eggplants, capsicums, potatoes, and chilies can all be considered as one type of vegetable because they are all from the same family of plants – Solanaceae. Cabbages, broccoli, cauliflowers, mustard, and kale are all the same family – Brassicaceae.

It is good to give each garden bed a rest for a few months, once every two years, to help it regain its stock of nutrients. During this time add lots of compost and mulch, and plant a green manure crop too.

If your soil has bad fungus disease problems you can grow clumping grasses, especially lemon grass, with legumes in your crop rotation cycles, and leave them to grow for a season or even a year. Read Integrated Pest Management (**Ch 14**) for more information about preventing and treating soil diseases.

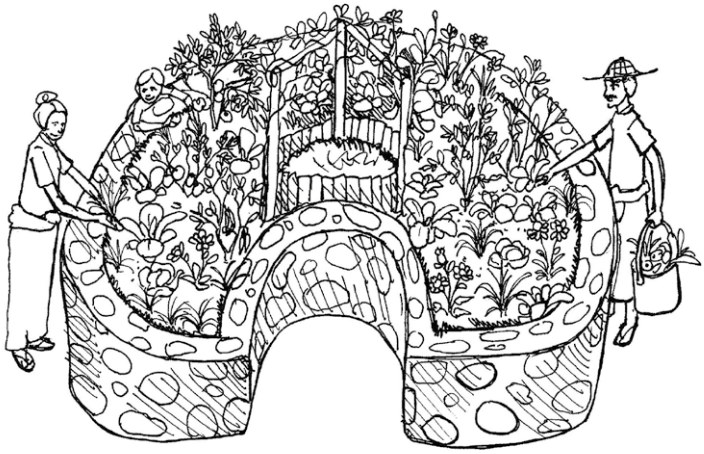


Example of crop rotation plan

INTEGRATING CROPS TOGETHER

We have shown you how to integrate crops which have different harvest times and heights, but there are many other reasons to grow several vegetables, fruits, spices, and even flowers together in the same garden beds.

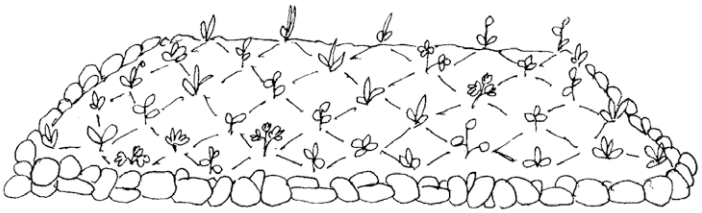
- Growing different crops together will reduce the size of pest problems because it takes more time for insects to move from plant to plant. Also there are fewer of each type of vegetable to attack, making pest problems easier to control.
- Combine plants that have similar watering needs. This allows you to be more efficient with water and your time.
- Place long-term vegetables and plants that need low maintenance and have one harvest at the back of the bed. If the bed has paths on both sides, place them in the middle. Put short-term, high-maintenance vegetables on the edges of the beds. This makes gardening easier and, importantly, reduces soil compaction.
- Some plants benefit from having other plants grow near them. For example, garlic helps to repel aphids. (An aphid is a very small pest that in large numbers can cause a lot of damage to tomatoes, cabbages, green vegetables, and other crops) Therefore, any plants that aphids could attack benefit from garlic growing nearby. Garlic will not stop all aphids but it discourages them and reduces their numbers. Look in Integrated Pest Management (**Ch 14**) for more ideas.
- Planting flowers and herbs in garden beds attracts insects that increase the pollination rate of vegetables. Insects that feed on pest insects also increase in number and help to reduce pest problems.
- Beauty is important in any garden and integrating different plants together makes a much more beautiful garden.



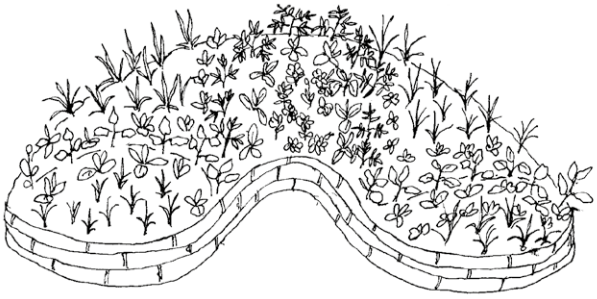
Integrating many different crops together

SMART IDEAS:

- Some garden beds should be for seasonal crops only, especially dry season crops.
- You do not have to plant vegetables and other plants in straight lines. Different patterns can increase the number of plants in a garden bed.



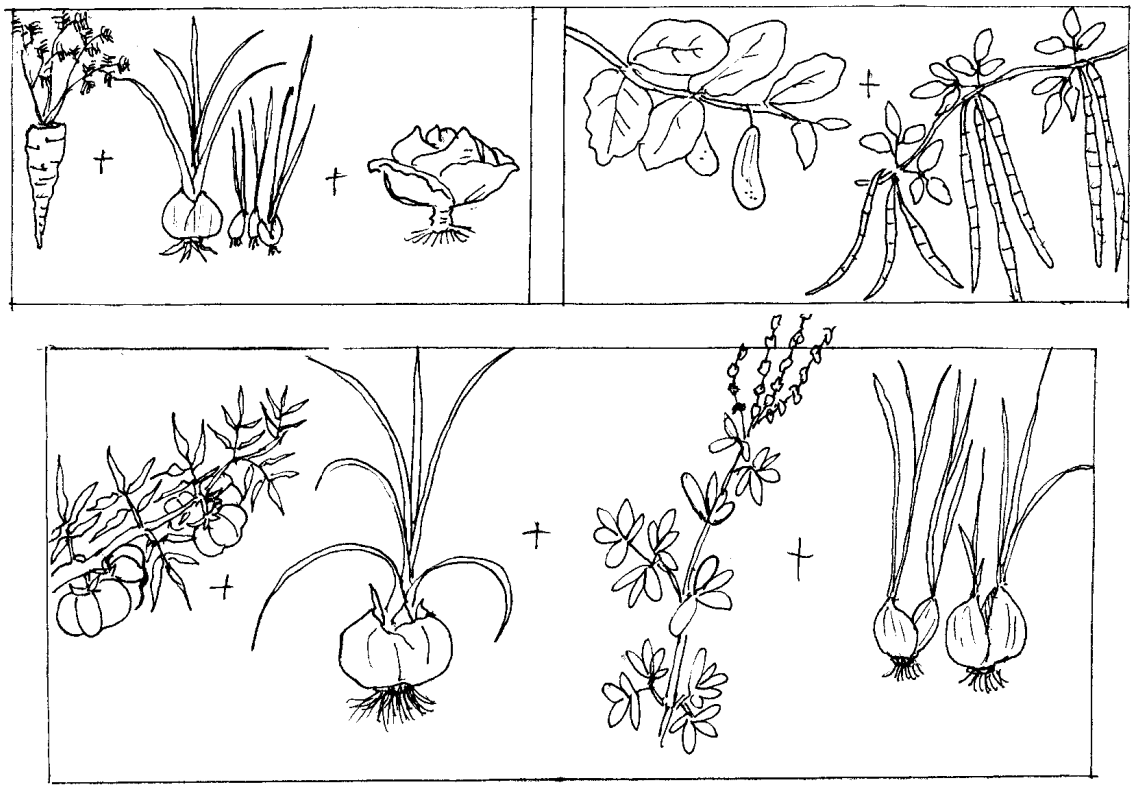
Zigzag pattern increases the number of plants in a garden bed



Integrating different crops

VEGETABLE COMBINATIONS

- A common wet season combination is corn, pumpkins, and beans together.
- Tomatoes, garlic, and basil grow well together and help to protect each other from pests.
- Chili plants and eggplants are also good for tomatoes, but potatoes are not.
- Sunflowers are good to grow around corn to help to reduce pest problems.
- Cabbages like onions growing with them to help repel insects and tomatoes are good too. Carrots grow well with onions, cabbages, and lettuces.
- Cucumbers like beans and peas growing next to them.



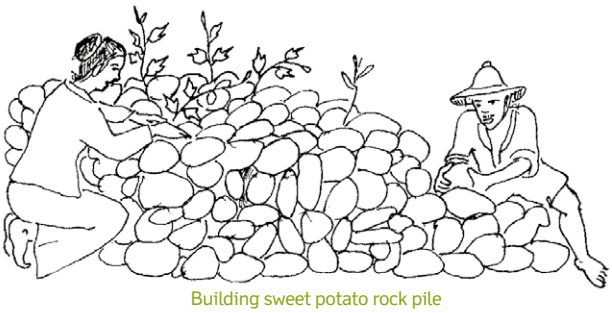
Different good plant combinations

SWEET POTATOES AND TARO

Another combination is sweet potatoes and taro, but not because they deter insects. This method is particularly good for ground with a lot of rocks.

Start by making a rock pile. The pile should be about 2 metres by 2 metres when it is finished. Use large rocks, hand size or bigger, so that there are lots of gaps.

Next to the rock pile start digging a shallow pit, about an adult hand length deep. Use the rocks you dig up to help make the pile. Use the soil you dig up to fill in the gaps in the rock pile.



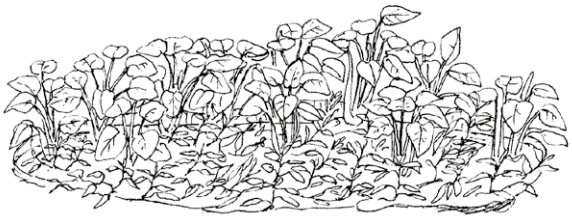
Building sweet potato rock pile

Digging taro pit and adding soil to rock pile

Add sweet potato cuttings as the rock pile grows. Keep adding soil, rocks, and sweet potato cuttings until the pile is 1 metre high or more.

Use more rocks on the outside and more soil on the inside. The result is a pit that can be used to grow taro and the sweet potatoes grow out of the pile. The rocks protect the sweet potatoes from rats. Do not forget to add some compost or dry manure–some liquid compost is also good–and sweet potatoes love extra ash. Water the garden every day for the first week. Place cut banana stalks as mulch in the taro pit, as they help to keep the moisture in.

Sweet potatoes growing



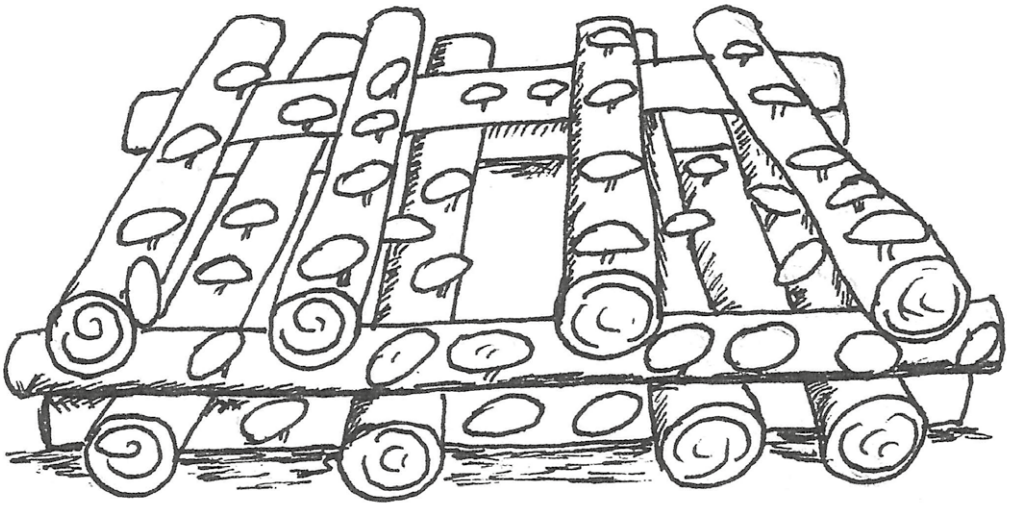
Taro pit growing

Integration with mushrooms

Mushrooms are 'fruit' from some types of fungi. They are excellent to have in your garden, a great source of protein and vitamins – especially vitamin B – and are very tasty!

They also play an important role in soil and plant health, and provide other functions too. Many mushrooms have a natural relationship with plant roots: they feed on sugars and in return help plants to obtain water, nutrients, and minerals from further away in the soil.

Some mushrooms are so small they live inside plant roots! They help plants to grow better, especially in extreme conditions.



Cultivated mushrooms growing on branches

Mushrooms can also help in the family garden and animal systems to improve production:

- Oyster mushrooms eat some types of nematodes (microscopic worms that live in the soil and damage plant roots).
- Pig love mushrooms! Feed them any edible mushrooms not good enough quality for selling or eating.
- Organic mushroom compost (specially made compost used for growing mushrooms) is still high quality when mushrooms have finished growing. It can be added directly to garden beds, into compost or used to grow insects to feed to chickens, ducks, and fish.

MUSHROOMS TYPES FOR EATING

It is good to identify and grow local edible mushrooms because these fungi grow well in your region already. Make sure all the mushrooms you grow are known to be edible and do not cause any sickness!

Introduce the mushroom spores (like microscopic seeds) and 'base' into the garden. The base is the part of the mushroom fungus that lives in the ground from which the mushrooms grow. The best method is to take some soil and/or plant material from where the mushrooms grow. Add this directly to your garden beds or to a mushroom growing space. Look at what the mushrooms grow from and add this material or something similar to the garden beds/growing space as well.

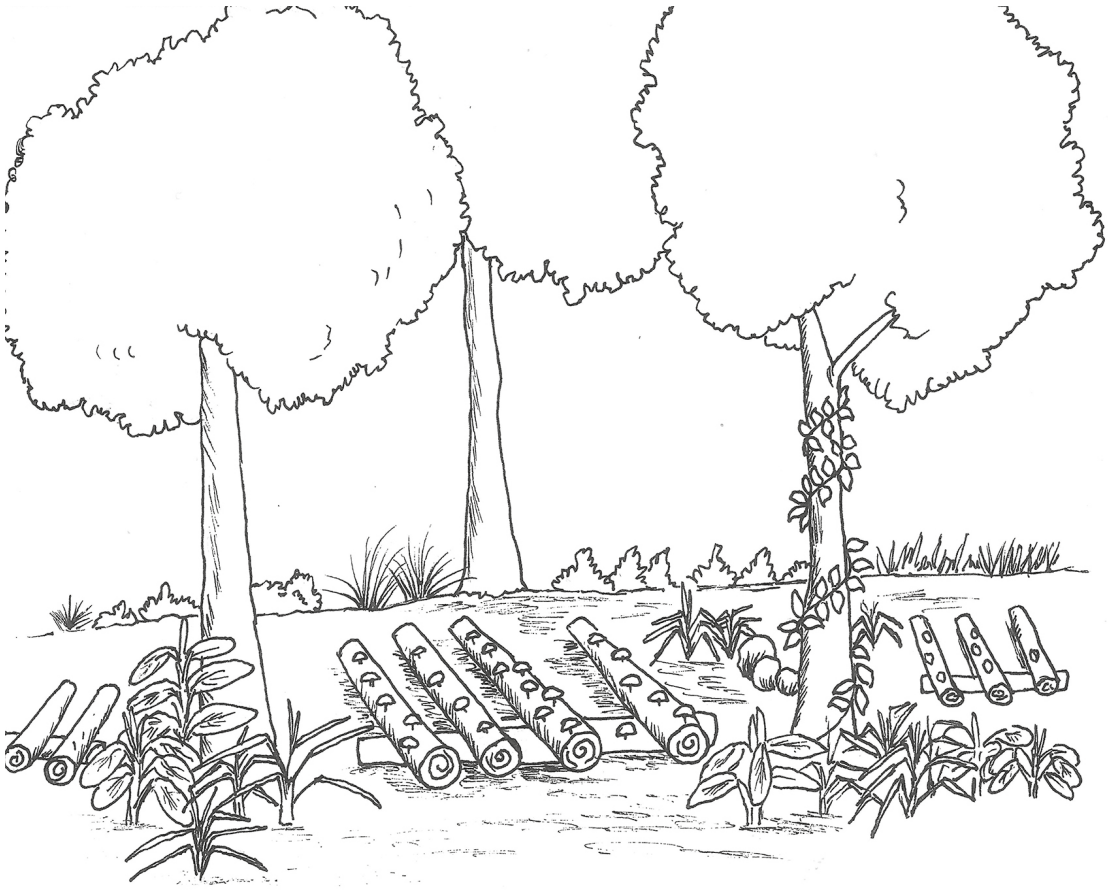
As they grow, common mushrooms assist in decomposing not only wood, vegetation, and manures but insects and animals too. Vegetation to grow mushrooms from includes different types of wood (branches and saw dust), rice husks, rice straw, corn stalks, and sugar cane straw (remains from processing). Some mushrooms even grow on used coffee grounds.

Harvesting edible mushrooms from the garden

MUSHROOM MAINTENANCE

It is very important to copy the mushrooms' natural growing conditions. This varies with different mushroom types and includes:

- The right amount of shade
- Soil pH: if the mushrooms like acidic soil, you need to prepare a separate growing area for them.
- The right amount of moisture
- The right temperature
- Soil type: sandy or clay or a mix of both
- Canopy trees: collect leaves from the same trees under which the mushrooms like to grow, and include these in the mulch.
- The right type of wood/plant material that the mushrooms grow on: these can be collected (but do not remove too much wood and damage the forest: it is better to grow your own wood and add the mushroom spores to it). The wood can be used as garden borders.



Once you have them they are easy to maintain but you **must not** use fungicides or other chemicals that could kill the mushroom spores and base.

Feed the mushrooms in the garden beds with manure, compost, leaves, and mulch.

One technique from Timor-Leste is to cut up the trunks of old papaya trees, lay them on top of a compost heap, then cover them with thin cardboard or old newspaper and wet it very well. Edible mushrooms grow within days and are produced for a week. Using the same system, oyster mushrooms like growing on old mango branches, but only if the fungus spores are already present.

Many countries have mushroom growing businesses: you can use their old soil which contains the mushroom spores and fungus base. These types of mushrooms require more maintenance and sometimes do not live well together with local bacteria and fungi. Some require a separate growing room where other fungi and bacteria cannot affect them and where you can regulate oxygen, moisture and temperature.

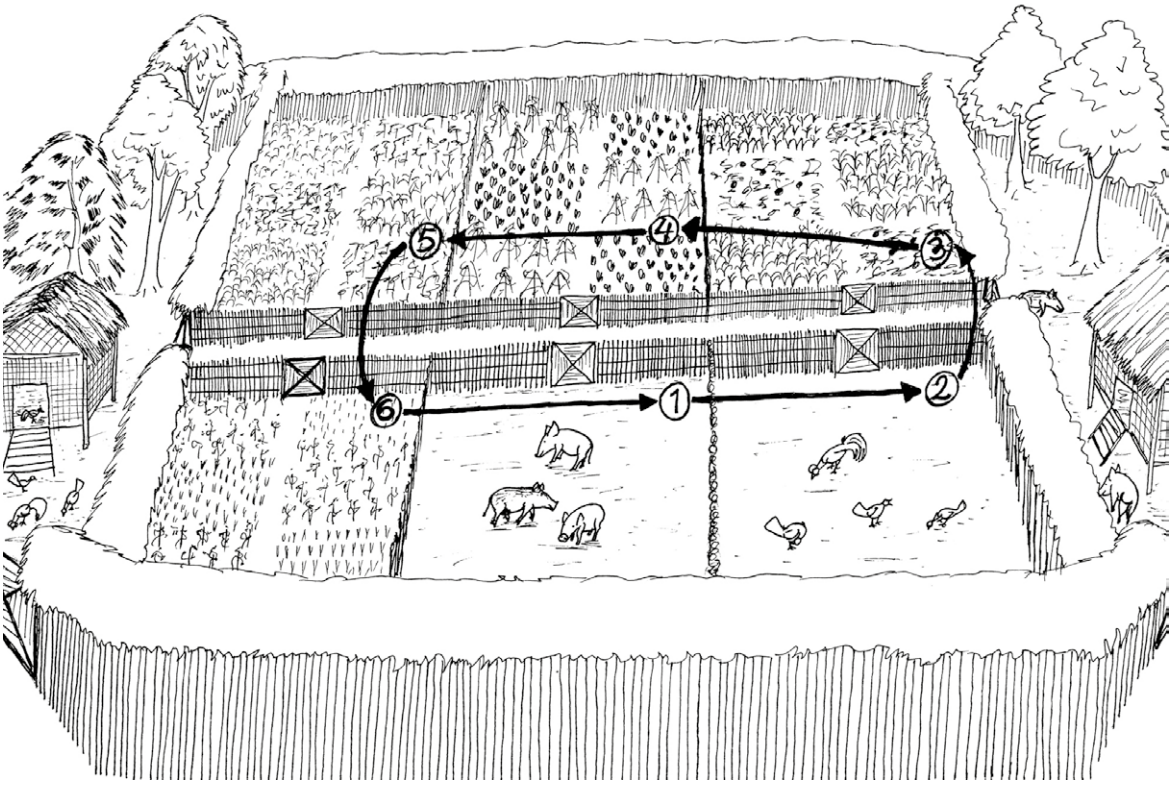
Read Sustainable agriculture (**Ch 13**) for more mushroom growing techniques.

Integration with animals

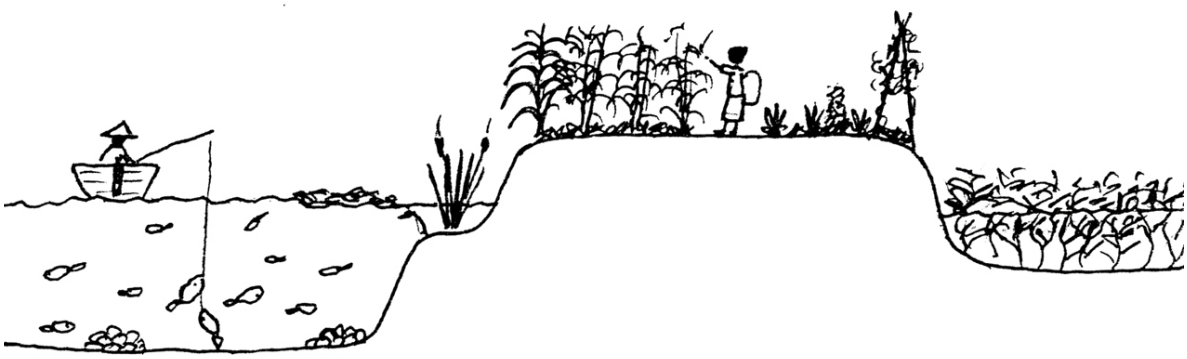
The manure from animals is food for your vegetables, and the weeds and vegetable stalks are food for your animals. However, integration can go much further: chickens, ducks, pigs, and fish can all be raised together with vegetables.

- Areas of land can be rotated between vegetables and animals.
- Animals can be used to clean weeds and insects after crops, and fertilise as they clean.
- Chickens and pigs can be put in small movable houses each day to clean and fertilise the soil. They are called 'animal tractors'.

Look in Animals (**Ch 17**) for many more ideas on animal and vegetable integration.



Animal and vegetable rotation system



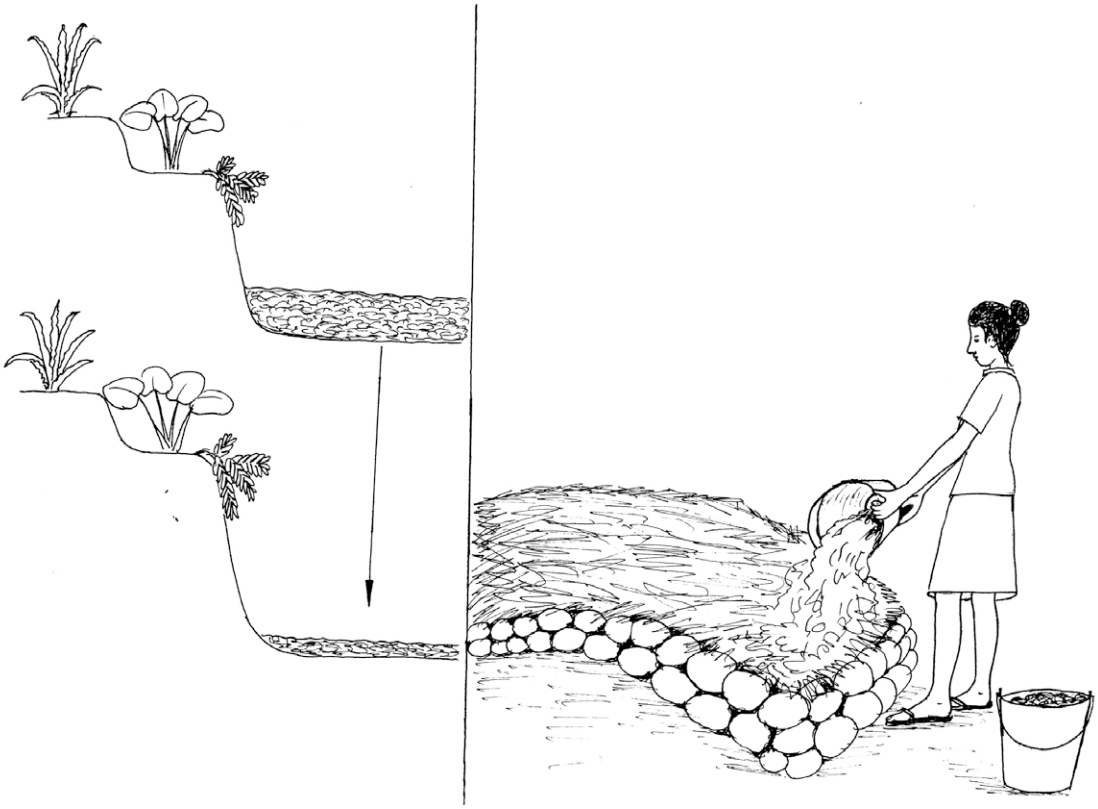
Integration with fish

Fish ponds can be easily integrated with family gardens.

They:

- Increase the amount and diversity of production
- Provide rich fertiliser for the gardens
- Attract pest predators

Aquaponics directly combines fish and vegetable production and is especially good for small spaces and urban areas. Read Aquaculture (**Ch 18**).



Removing pond soil to use as fertiliser on garden beds

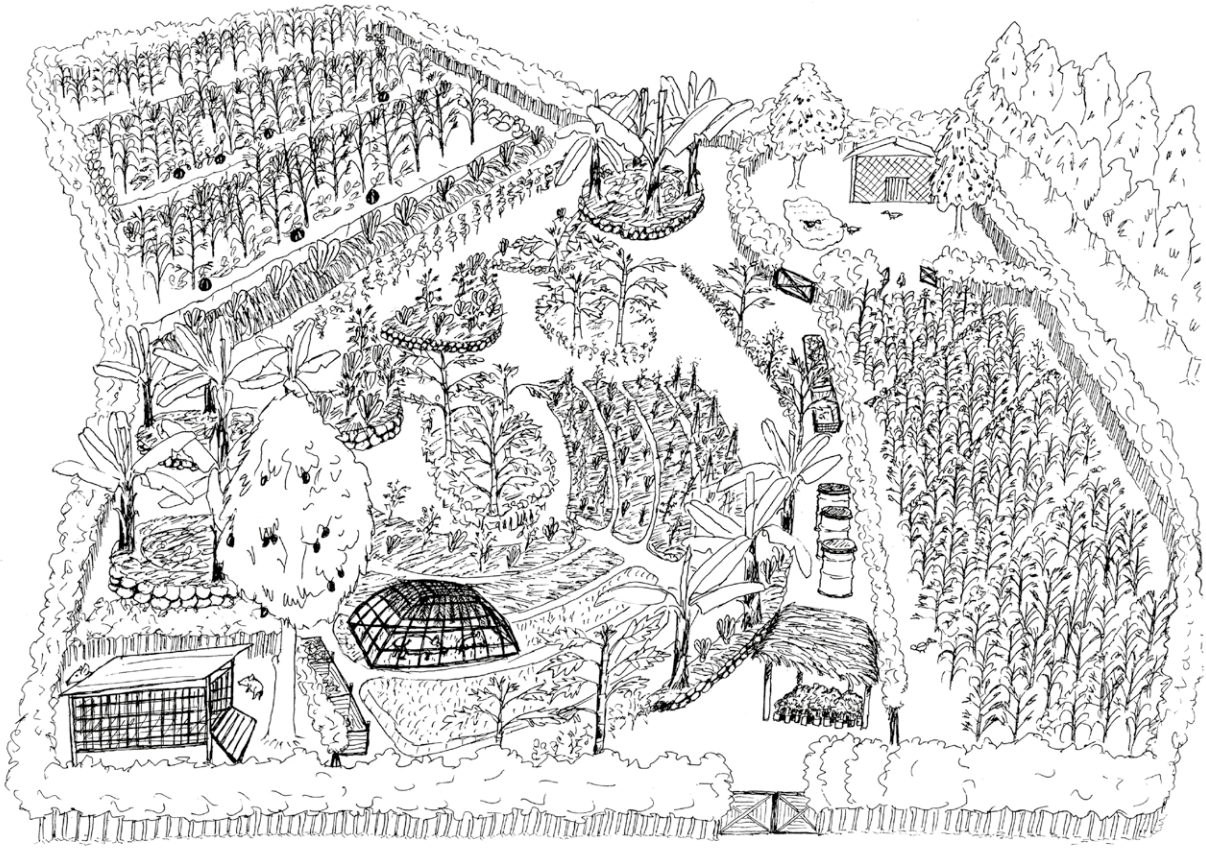
To finish...

Every location is different and every garden should be different too. Your systems can be as big or small as you want. Importantly, the system should fit with the natural pattern of the land and with your needs. If this happens then every system WILL be different.

Everyone needs a wide variety of vegetables to be strong and healthy. Gardens can provide vegetables, and also fruit, spices, and medicines for a very small cost.

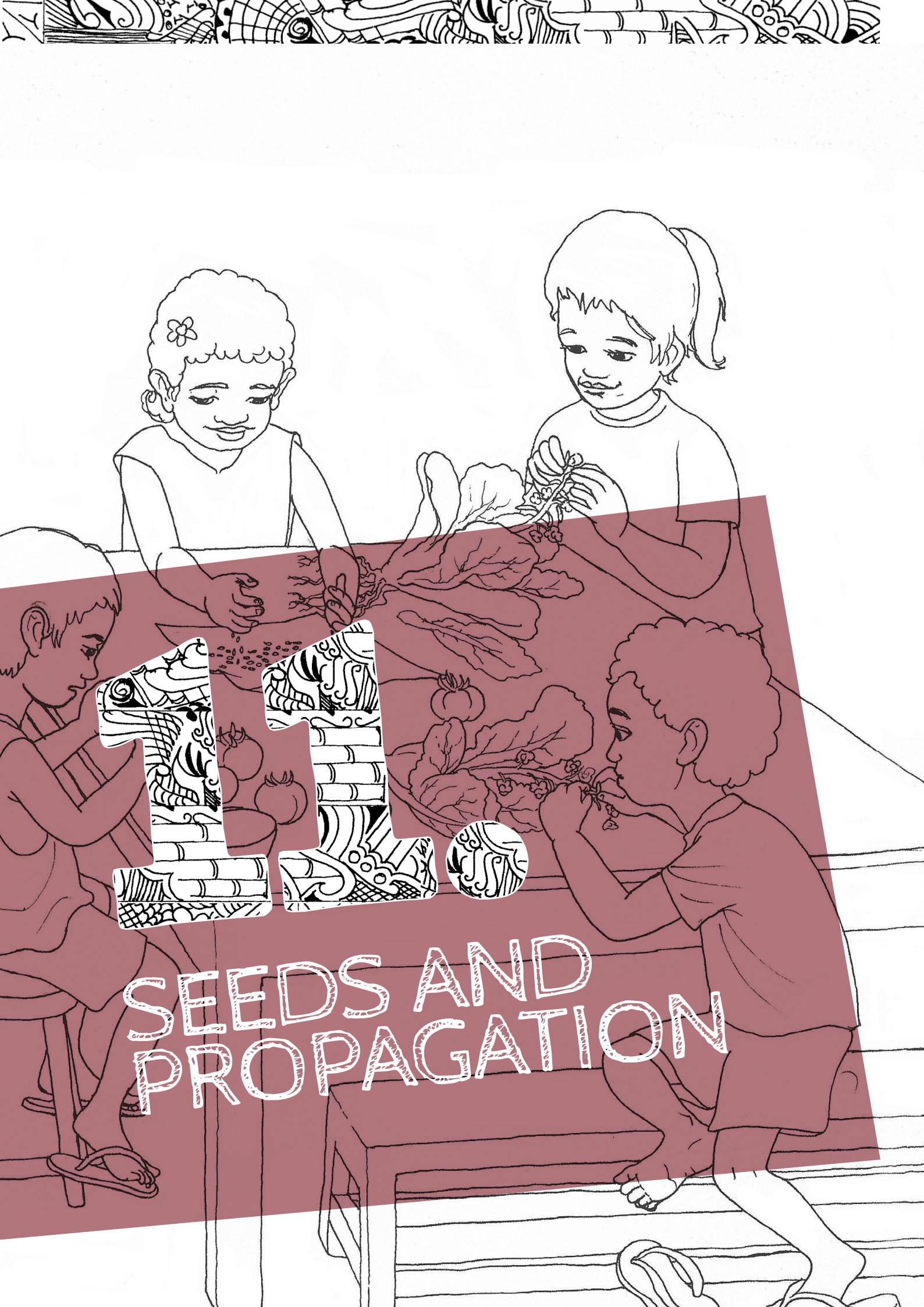
Remember to start small, make a garden that works well, and is protected from animals. Expand your garden as you need. Remember to reuse all the water from the kitchen and washroom, as this is a valuable resource. Remember to work smart, not hard.

A lot of food can be grown in a very small garden.



An integrated and intensive garden with animals, small fruit trees, windbreak, living fences, small nursery and organic fertiliser production

FAMILY GARDENS
CHAPTER NOTES



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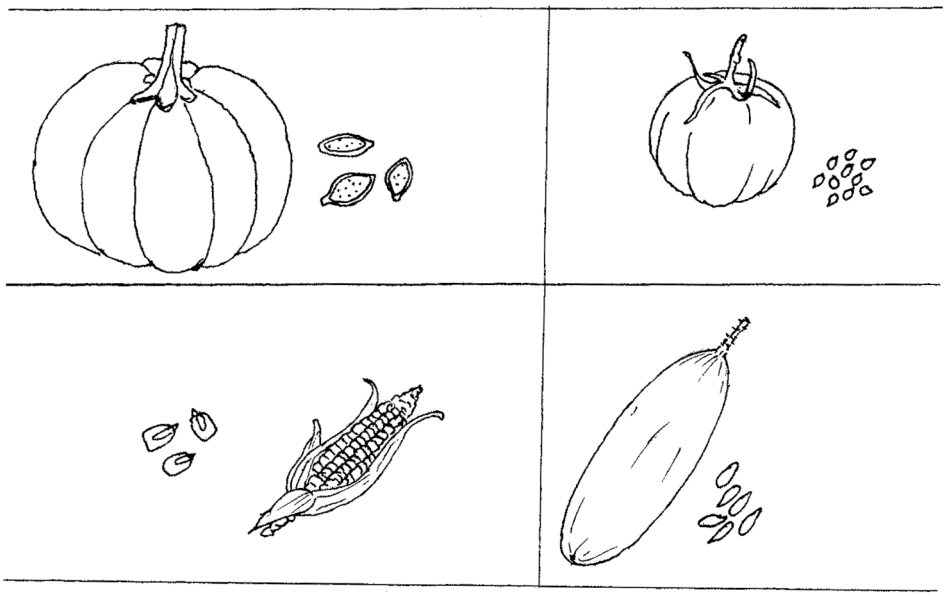
Saving and using local seeds is one of the most important methods for strengthening agriculture, increasing the variety of plants, and achieving food sovereignty.

WHY SAVE SEEDS?

- Everyone can collect and save seeds: it is cheap and easy to do.
- Saving and exchanging local seeds will increase the amount and variety of food that is grown.
- Local non-hybrid seeds generally have a higher nutritional content.
- Seeds are valuable and can be exchanged for other seeds or sold through a community seed bank.
- When good techniques are used for selecting and saving good seeds, the plant quality naturally improves each year.
- If there are no local seeds available, families and farmers have to buy seeds and are reliant on companies rather than on themselves. This decreases community resilience.
- A well-stocked seed bank containing proven local varieties is one of the best protections a community can have against the uncertainties brought by climate change.

Local seeds have adapted to local conditions.

This means that they are used to the climate and the soil where they grow. Each year that seeds are collected and planted, the plants become more adapted and stronger. If someone from Timor-Leste goes to live in England, or someone from Costa Rica goes to live in Kenya, it will take them many years to adapt to the climate, people, language, food, and culture! It is the same for seeds and plants. **The plants that grow the healthiest and strongest are the plants from which seeds must be saved.**



Every country has a large range of fruit, vegetables, grains, and other crops. These plants can be given local names to make trading and identification easier. New varieties of plants can also be grown to add to the range of different plants in your community, e.g. okra, kale. Sometimes introducing a new type of grain, fruit or vegetable can increase the yield of a crop, e.g. a new type of pumpkin.

To improve production, first consider the soil quality, amount of nutrients, water and sunlight. These are usually the most important factors. Then think about the type of seeds.

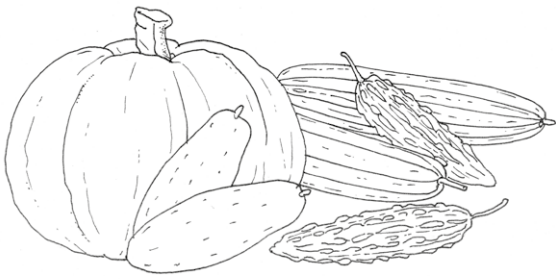
PLANT RELATIONS

It is important to understand the classification of plants as it is then easier to understand the following information on pollination, cross-pollination, non-hybrids and hybrids, and creating new plant varieties.

Plants are divided into different groups using the following system, with the tomato and pumpkin shown as examples:

Order	Botanical name – Tomato	Botanical name – Pumpkin	General description
Kingdom	Plantae	Plantae	Plants
Subkingdom	Tracheobionta	Tracheobionta	Vascular plants
Superdivision	Spermatophyta	Spermatophyta	Seed plants
Division	Magnoliophyta	Magnoliophyta	Flowering plants
Class	Magnoliopsida	Magnoliopsida	Dicots
Subclass	Asteridae	Dilleniidae	
Order	Solanales	Violales	
Family	Solanaceae – nightshade family	Cucurbitaceae – Gourd family	
Genus	Solanum L.	Cucurbita L.	
Species	Solanum lycopersicum L. – garden tomato	Cucurbita mixta Pang. – pumpkin	

Solanaceae family



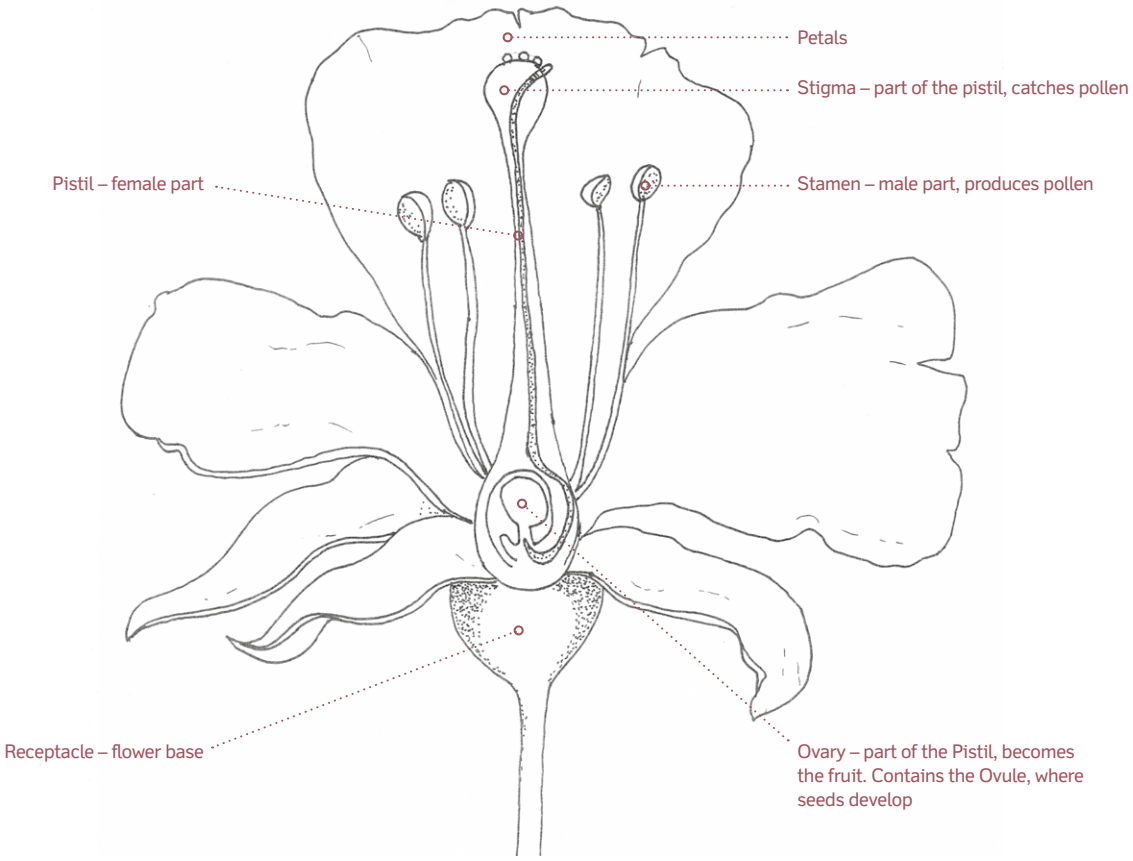
Cucurbitaceae family

Most plants you can grow vary at the family, genus, and species levels. Using the above examples, the Solanaceae family contains tomatoes, potatoes, eggplants, chilies, capsicums and tobacco. The Cucurbitaceae family contains cucumbers, pumpkins, gourds, squash, and zucchini. Generally seeds are produced from one species or from crossing two different species from the same genus. In nature two different genuses sometimes but rarely cross to form a new plant.

POLLINATION

Pollination is the process a plant uses to make fruit and seeds.

During pollination, pollen from the male part of the plant fertilises the female part of the plant. These pollinating parts are usually found in the flower. Once the female part of the plant has been pollinated, the plant will produce fruit and/or seeds.



Different plants use different pollination techniques to produce seeds.

1. Beans, lettuces, tomatoes, cabbages, and chilies are examples of plants that have the female and male parts in the same flower.
2. Pumpkins, melons, cucumbers, and corn are examples of plants that have separate female and male flowers on the same plant. These plants all require insects, the wind or humans to pollinate by hand to reproduce.
3. Some papaya varieties have separate female and male plants and, therefore, require more than one plant to pollinate.

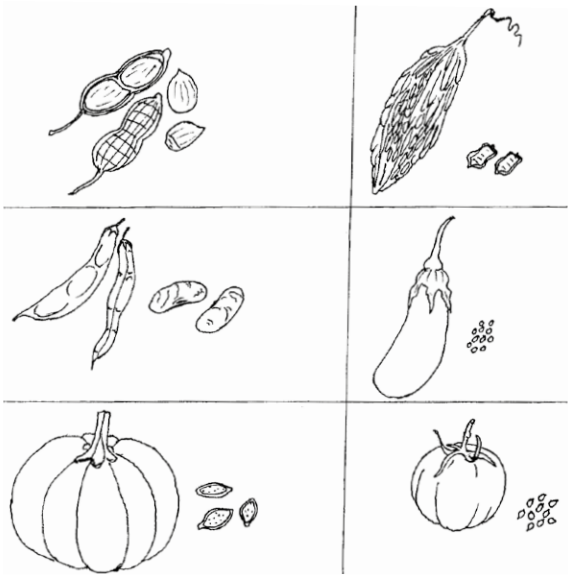
SMART IDEA:

More insects in the garden lead to better pollination rates, which lead to more and better quality seeds. Flowers, food, and water attract insects. If you have healthy soil and a large variety of trees and plants, you will have plenty of insects to pollinate your plants. A pond or ponds will also help.

CROSS-POLLINATION

Cross-pollination is the transfer of pollen from the male part of a flower of one plant to the female part of a flower of another plant. It occurs naturally or it can be done by humans. Cross-pollination mostly occurs at the species level, depending on the plant family, and sometimes at the genus level.

Cross-pollination of different types of plants occurs when two different but closely related varieties pollinate each other, e.g. two different types of green-leaf vegetables, or two different types of corn, or a pumpkin plant and a squash plant. If this occurs, the resulting seeds might be good, sometimes they will be weaker than the parent plants or they may not grow at all, especially if two different genuses cross. Therefore, it is best to try to prevent cross-pollination of different plant species from occurring unless you want to cross-pollinate.



Some techniques to reduce the chances of different types of plants cross-pollinating are:

- Grow one type of each plant at a time, e.g. one type of corn or one type of pumpkin or squash or one type of eggplant.
- Plants such as green-leaf vegetables, lettuces and cabbage flower and set seed at the end of their life. Have only one type of green-leaf vegetable or one type of lettuce or one type of cabbage set flowers and seeds at a time.
- If different types of a plant are far apart from each other, and many other plants are grown in between, the chances of cross-pollination are reduced. Beans, tomatoes and plants that have closed pollination where the flower pollinates without opening require a 10m distance to be safe, plants that use insects and wind for pollination require a lot further. Bees can travel up to 5km!

Hand pollination: pumpkins, melons, luffas, gourds, chokos, and cucumbers can be pollinated by hand.

If these vegetables are pollinated naturally, they can cross-pollinate with other types of the same vegetable. They cannot cross-pollinate with other vegetables, e.g. only pumpkin-pumpkin, luffa-luffa, etc.

Hand pollination allows you to choose the exact type of seeds you want to collect.

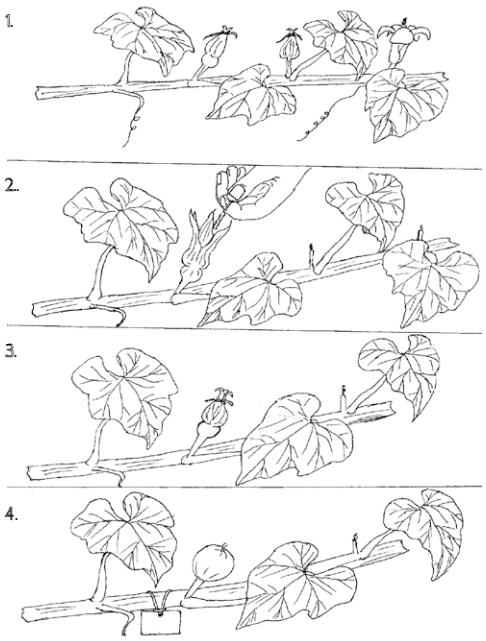
SMART IDEAS:

- Repeat the process on other female flowers using male flowers from different plants of the same type, e.g. from different pumpkin plants that all produce the same type of pumpkin. This helps to keep seed quality and diversity.
- Use this method to cross pollinate different varieties to create a new variety. E.g. a new type of cucumber. This sometimes works and sometimes doesn't, so don't rely on these seeds to be your main crop.

Method:

These plants have male and female flowers. (The female flowers have small fruit below the flower.)

1. In the late afternoon, choose a male and a female flower that are just about to open. Tie them closed so that insects cannot enter.
2. Early the next morning open the flowers. Carefully pick the male flower, pull off the petals and rub the pollen-covered middle (stamen) inside the female flower.
3. Retie the female flower.
4. When the fruit starts forming, loosely tie a piece of string or material around the base of the fruit so you can find that fruit later to save it for seed.



KEEP YOUR SEED STOCK STRONG

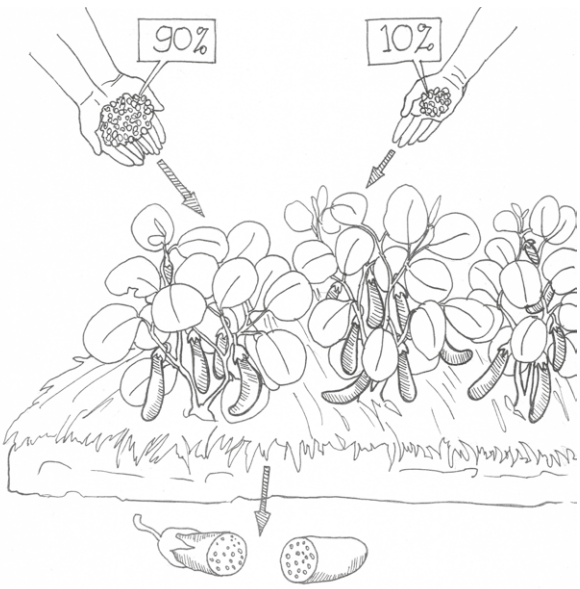
It is good to refresh your seed stock every few years. To do this you need to cross your existing seed stock with seed stock from somewhere else. This helps to keep your seed stock healthy and productivity high.

Grow plants from your seeds together with plants from the new seed stock. A mix of 90% of your seeds with 10% of the new seeds will ensure that your seeds are the strongest but that cross-pollination also occurs.

Always select high quality seeds with which to cross-pollinate:

- Cross your existing variety with seeds from the same species but from a different farmer or area. Seeds from an area with a similar climate are good.
- You can cross-pollinate with seeds that you buy but make sure that you know that the seeds give good results for your land and your climate before you use them.

Vegetables test plot with labels



Introducing fresh seed stock (10%) to keep quality high

SMART IDEA:

Grow a test crop first to find out if the new seeds grow and produce well. A simple test is to grow three small areas of a new type of vegetable in garden beds of 3m x 1m each. Each test site should be in a different area but using the same techniques. If the crop grows well, it can be grown in large plots the next year. This idea helps to increase the variety of crops grown, but it does not waste a lot of time, work and money if the crop does not grow well.

NON-HYBRID SEEDS

Non-hybrid seeds are produced when plants are natural pollinated. This can happen through open pollination, which occurs naturally through insects, the wind, birds, etc., or closed pollination where the flower pollinates without opening, e.g. beans and peanuts. Non-hybrid seeds are sometimes called heirloom or open pollinated seeds, and some varieties have been around for centuries.

Non-hybrid seeds can be saved each year. Plants, such as tomatoes and beans, can be relied upon to produce seeds that grow like the parent because of the way the seeds are produced. Plants, such as lettuces and corn, can easily cross-pollinate because of the way pollination occurs. It means the results can vary unless pollination is carefully controlled, and only one species is allowed to flower and seed at a time. Seed stock quality can be improved each year if good seed saving techniques are used.

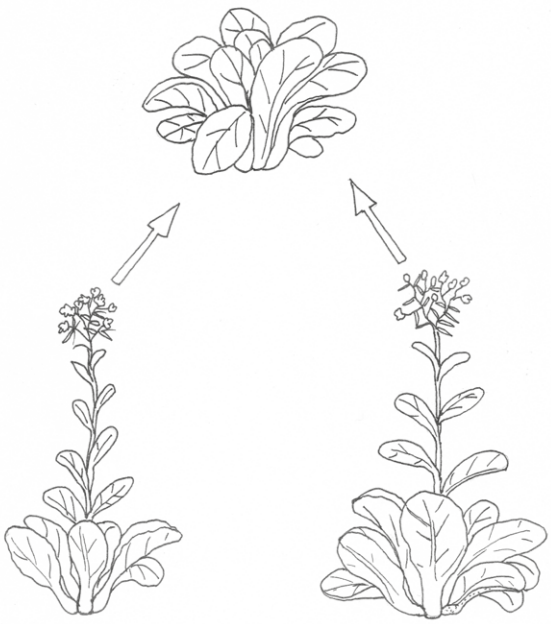
All traditional varieties of vegetable, grains, and fruit seeds are non-hybrid.

Healthy plant tagged for saving seed

HYBRID SEEDS

Hybrid seeds are created when two different plant varieties are crossed during pollination to create a new variety. This can happen accidentally if two varieties of the same species or genus are flowering at the same time and cross-pollinate, but it mostly happens when a farmer or seed business is looking to create a new seed. Hybrid seeds also come from open and closed pollination plants.

Hybrid seeds bought in a packet will produce similar plants and can usually be used for seed saving. However, the seeds from those hybrids can vary in their characteristics and the results from the next crop are unknown. Hybrids seeds will not be used to the local conditions and may suffer problems as a result. You can ensure resilience and the quality of seeds that are saved from hybrids over a few generations by using good seed saving techniques explained in this chapter.



Cross pollinating two different varieties to create a hybrid

F1 Hybrids: any packet with "F1" on it is a hybrid that cannot be used for saving seeds. This is because of how the seeds are produced. Seeds collected from F1 hybrid will not be the same as the plant: they will be either one of the weaker parent plants or they won't grow at all. Avoid F1 hybrids for seed saving and for creating local seed stock.

Example of F1 hybrid seed packet

From a farmer's perspective, local seeds are resilient, dependable, and free. Local seed quality can be improved using simple techniques. Hybrids can give good results but cost money every year. Hybrid seeds, especially F1, are more likely to be attacked by pests and disease, which costs time and money.

Businesses want to sell lots of seeds, and they often also sell pesticides and herbicides. It is important for farmers to see the results before they believe what businesses say, and especially to understand the long term effects of chemicals on soil quality and production.

With natural cross pollination, hybrids, and even with F1 hybrids, natural laws are followed by farmers, scientists and business who work only with plants from the same families to create new seeds.

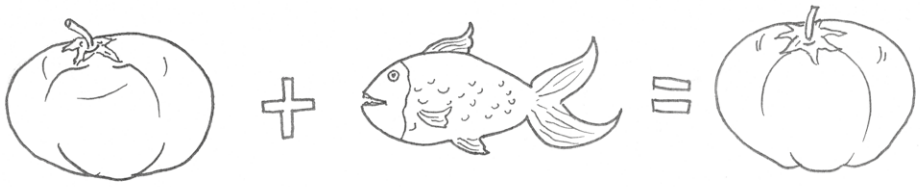
GM seed pack

GENETICALLY MODIFIED (GM) SEEDS

We strongly recommend NOT using GM seeds. They are a new form of hybrid where the seeds are modified genetically in a laboratory. GM seeds break all natural laws, as new seeds have genetics from not only other plant families but from animals too!

Scientists also change the genetics within the seeds. Most GM seeds have been changed by the seed manufacturers so that they only grow once, and any new seeds that come from them will never grow. They call it the terminator gene.

It can produce good yields in the short term, but the costs are high and over time farmers become locked into using GM seeds and the chemicals that go with them. Also, the yields usually decline year by year.

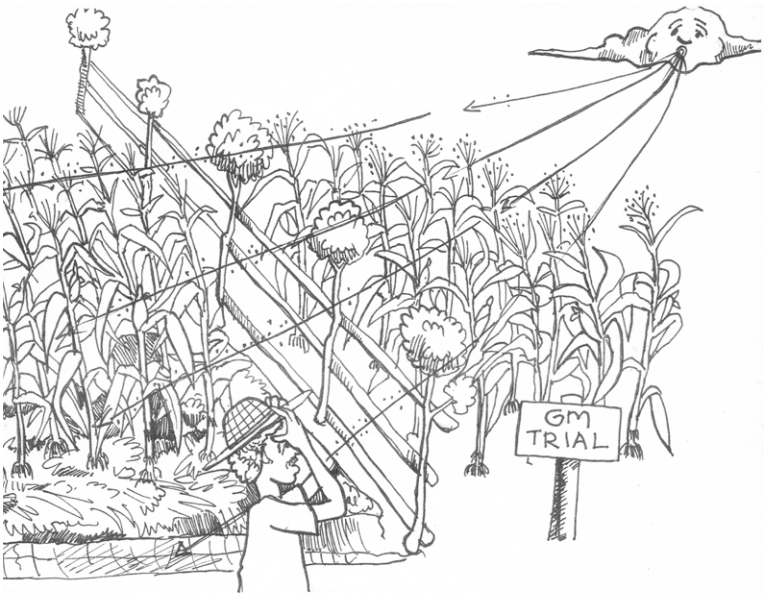

Adding fish genes to a GM tomato

THERE ARE OTHER PROBLEMS TOO:

- **Because the seeds have been modified, the company which makes them can own them because they are no longer made by nature.** This means that you have to buy the seeds every year. If you save their seeds and use them, the company can take you to court for using their property. We think it is wrong for companies to own the rights to seeds because it takes away a basic human right to be able to own your seeds and control your own food supply. We advocate food sovereignty for all people.
- **GM seeds do not grow well using organic farming techniques.** The seeds are sold in a package with chemical fertilisers, pesticides, and herbicides and farmers need to use these to obtain good yields. This is expensive: farmers and their families are under great stress from financial debt caused by buying the seed package. The associated chemicals damage the soil, the water, the insects, and the environment and farmers become dependent on them to obtain a yield, which creates more damage until the soil is unusable, the water polluted, and the environment is heavily degraded.
- **Farmers are exposed to toxic chemicals**, especially because it is often hard to understand the instructions, leading to overuse. This can lead to many health problems, not just for the farmers but for their children too.
- **GM seeds are, by necessity, grown as monoculture crops.** This leads to less diversity, more pest problems, and higher pesticide use.

COMMUNITY AND NATIONAL PERSPECTIVE:

- Tell your neighbours not to use GM seeds! Once a farmer uses them, the land around is degraded and the GM seeds can cross-pollinate with other crops.
- Tell your government not to allow trials. Often tropical countries do not have strong laws protecting their natural genetic resources. It can also be easier for companies to influence poor countries and trial GM seeds in these countries to research results. Whether the trials work or not, cross-pollination can occur, impacting local seed stock.



GM seed pollen mixing with local variety of corn

LOCAL SEED CALENDARS

Making local seed calendars will help you and your community to know when different seeds are ready for harvest.

There will sometimes be differences in actual seed harvesting time due to climatic variations from year to year, but a calendar is still very useful and it is a great way to record local gardening knowledge. Calendars are especially handy for recording times for native seed collection. It is good to divide the calendar into vegetables, fruits, and natives. Sometimes links to knowledge of local environmental patterns can also be made, e.g. the seed of a particular native tree might be ready at the same time as seasonal insects, such as dragon flies, appear. This is more accurate than a fixed calendar because both events will vary with the climatic differences, and they will happen at the same time as each other even if the time it happens varies slightly from year to year.

HOW TO SAVE SEEDS

Saving your own seeds and storing them correctly will provide you with free good quality seeds that you can use for many seasons.

Step 1: Healthy strong plants

To produce quality seeds, the first step is to grow healthy strong plants.

Healthy soil, compost, and mulch are the best way to produce healthy plants. Read the Soil chapter (**Ch 9**).

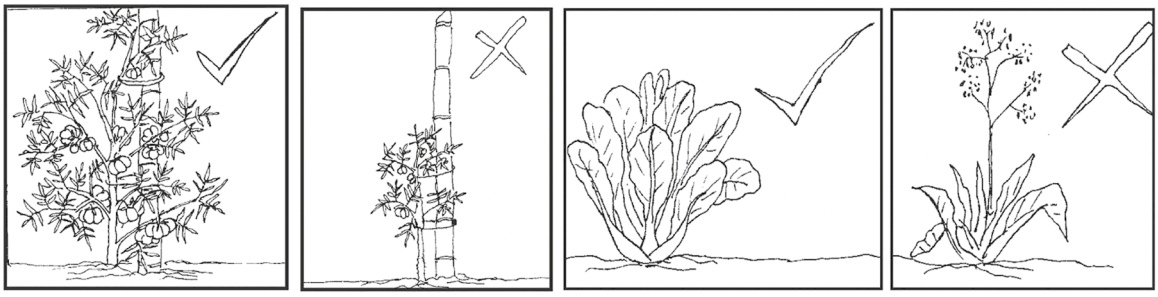
Compost methods

Step 2: Choose the best plants

Always pick the BEST plants to collect the seeds from.

The best and healthiest plants:

- Produce healthy and tasty fruit or leaves
- Are disease free and naturally resistant to pests
- Are able to withstand extremes, e.g. able to cope with very dry or very hot conditions or still grow well in poor soil
- Are slow to go to seed. For green-leaf vegetables, lettuces, and similar vegetables collect seeds from the plants that are the LAST to produce flowers and seeds, not from the first.



Choosing the best plants for collecting seed

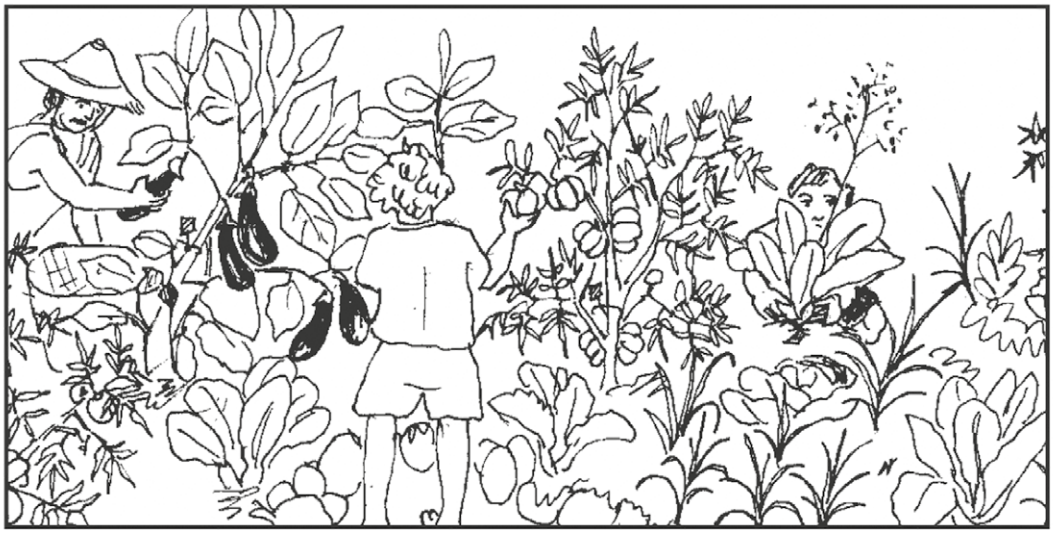
Select seeds from many plants to ensure a strong, healthy and diverse seed stock for the future. If you are growing trees, e.g. teak, select seeds from many different teak trees. It is the same for all vegetables, fruit, grains, and other plants.

When you collect seeds you pass on the characteristics of the plant to the next crop. If you choose healthy plants you pass on good quality characteristics; if you choose unhealthy plants you pass on bad characteristics.

Choosing the best plants for collecting seed

Step 3: How to collect the seeds

- Label the plants that you want to collect seeds from so that they will not be harvested for food.
- Wait until the vegetable/fruit/grain is ripe before picking. This means leaving the vegetable/fruit/grain until it is passed the edible stage. Young edible fruit has young seeds that are not ready to germinate.
- The best time to pick the seeds is mid-morning on a dry and sunny day.
- In the wet season if the rain is continuous, you can pick the fruit, seeds or preferably the whole plant, and hang it up it next to a fire. Even a small amount of moisture makes the seeds rot.



Collecting seed from labelled plants

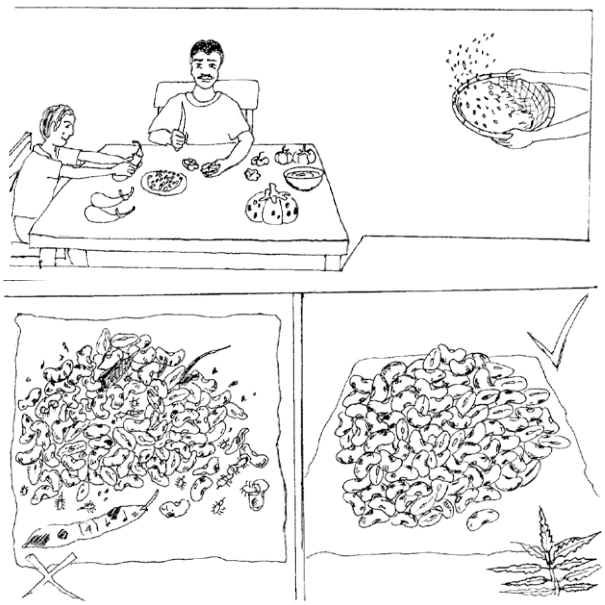
PLANTS	WHEN TO PICK SEEDS	HOW TO PICK THE SEEDS
Tomato, Eggplant	When they are ripe on the plant, slightly soft but not rotten. Pick from the early fruit to encourage early fruiting plants.	Hand pick the best fruit from the best plants.
Cucumber, Melons, Zucchini	Pick them about one month after you would pick for eating. (The seeds need to mature.)	Choose the best fruit from the best plants to leave for ripening.
Capsicum, Chili	When they are ripe on the plant (red).	Hand pick the best fruit from the best plants.
Lettuce, Green-leaf vegetables	Wait until the seedpods are brown and dry but not yet open.	Cover the seed heads with a bag then break main stem so no seeds will drop during collection.
Beans, Corn, Sunflowers	Leave them to dry on the plant in the dry season, pick them when ripe in the wet season and dry them near a fire.	Hand pick when the seeds are ready.

SMART IDEA:

Always pick more seeds than you need for the next season. This helps to prevent shortages due to insect or animal damage or the seeds rotting, and allows for replanting if some of the crop does not grow. Extra seeds can also be exchanged or sold through a community seed bank.

Step 4: Cleaning the seeds

- Seeds that have a dry pod/shell or husk are removed and separated by hand. Small seeds and pods can be placed in a bag, gently rolled and crushed to separate the seeds. Any leftover plant materials need to be separated from the seeds by winnowing or by hand. Sometimes it is easier to dry the seeds in their pods first and clean them afterwards.
- Seeds from eggplants, pumpkins and similar vegetables need to be scraped out and placed in a bowl of water. The seeds must be cleaned well and rinsed so that all the flesh is removed from the seeds. Then place the seeds out to dry.
- Tomato and cucumber seeds should be "fermented" to remove some diseases. First remove the seeds and some flesh from the ripe fruit. Mix the seeds and flesh with some water and leave them in a bowl for a few days. Foam will form on the surface showing that fermentation has happened. Then rinse the seeds well with water to clean them. All the remaining fruit flesh must be removed. Spread the seeds onto hard plastic, wood or metal, and put them in the shade to dry.



Cleaning seeds from vegetables

Step 5: Drying the seeds

This is a very important part of the seed saving process. If the seeds are not properly dried, they will rot when they are stored.

Seeds can be dried in whichever way you find best, but it is necessary to follow some practical guidelines for the best results.

- Spread the seeds out and air them. Shallow bowls, woven trays, old paper, and wire mesh can be used or large seeds can be put in woven bags and hung up to dry. The more air circulating the better. Turning them once or twice a day will allow all the seeds to dry.
- Protect the seeds from animals, especially mice and rats.
- Protect seeds from the wind, especially small seeds.
- Small seeds generally need one week to dry and large seeds one to two weeks to dry properly.
- Start the drying process in the shade or inside and continue for two days. You can place the seeds in the sun for half of each day: this will help to kill insects and their eggs. Bring the seeds back inside each night. In the wet season it helps to dry the seeds near a fire.

SMART IDEA: THE BITE TEST

Use the bite test to know if seeds are dry or not. Bite firmly on a seed. If the seed is hard and you leave no marks on the seed, they are ready for storage. If you leave teeth marks on the seed, they need more drying time.

STEP 6: Storing the seeds

After the seeds are dry they need to be stored well.

When seeds are stored correctly, many more seeds will grow next season. In a tropical climate seeds will rot quickly if they are not stored well. When in storage seeds need to be protected from:

- **Air** – it reduces the lifetime of the seeds.
- **Moisture** – it makes the seeds rot.
- **Heat** – it reduces the number of seeds that will grow next season.
- **Animals** – they damage or destroy seeds.
- **Insects and insect eggs** – they eat and damage seeds. If insect eggs are laid inside the container they hatch and the young insects will eat the seeds.
- **Light** – it damages the seeds and reduces the number of seeds that will grow next season.

To prevent these problems, first make sure that the seeds are well dried and clean. Then, on a dry and sunny day if possible, place the seeds in a container that will stop air from entering.

To reduce moisture problems you can cover the bottom of the container with wood-fire ash (not hot!), milk powder or very dry grain. These will absorb extra moisture.

METHODS TO REDUCE INSECT PROBLEMS

These methods are not for seeds that are for eating.

Wood-fire ash: Coat the seeds lightly in wood-fire ash and put some ash at the top and bottom of the container. **Do not** use ash from rubbish fires because it will contain chemical and toxic residues.

Neem: Put 1cm of dried neem leaves underneath and on top of the seeds. Bay leaves or guava leaves will also help.

Tobacco: Only use old, dry tobacco leaves. Place about 1cm underneath and on top of the seeds.

Gliricidia: Put about 1cm of dry Gliricidia leaves underneath and on top of the seeds.

Custard apple (Annona squamosa): Dry the seeds, and crush them to a powder. Add 2 tablespoons of the powder per large container of seeds and mix. Be careful as it can cause minor skin irritation.

Cold: In places where it gets very cold at night, put the seed containers outside each night for a week. Bring them inside again each morning. This will kill weevils (small white grubs/worms).

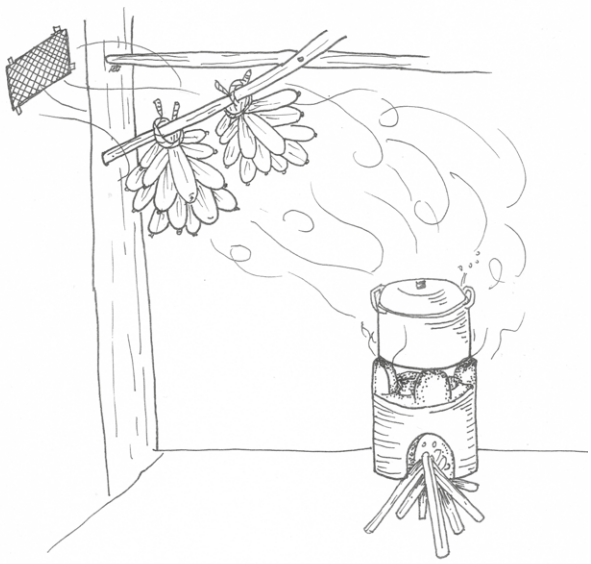
Salt: A small amount of salt mixed with the seeds controls some insects.

Smoke: Smoke is a preservative and a pest repellant. You can hang corn, seed pods and even whole plants above a fire as it helps to protect them from pests.

Oil: Large seeds can be coated with coconut oil to kill insect eggs. Put a small amount of oil in a large container, add the seeds, close the lid, and shake until the seeds are coated with oil. Small seeds, like lettuce and eggplant, cannot be treated in this way because the oil will damage them.

Larger seeds will generally last longer than smaller seeds.

Ash and tobacco will help protect your seed



CONTAINERS FOR SEED STORAGE

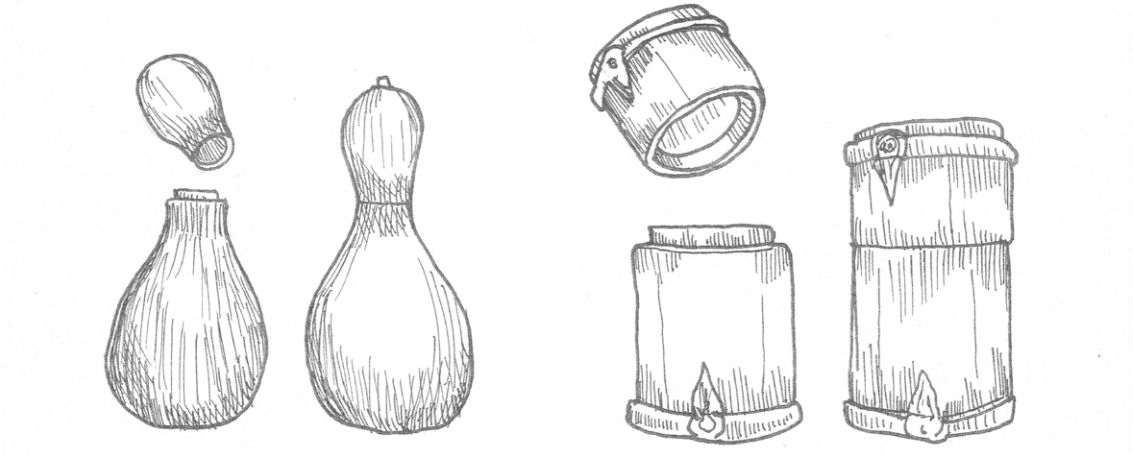
Tin cans and glass jars with good lids are very good to use. Water bottles and oil bottles are also good but be careful of rats and mice eating through the plastic.

Glass and plastic bottle containers need to be put in a box to stop direct light from damaging the seeds. Anything that is dry and sealable can be used as a container. Plastic bags can be used only if nothing else is available, but they need to be put into a container that stops animals.

One large sealed container stores many small bags of seeds. Store the containers in the coolest, driest and darkest place you can find. Protect them from animals.

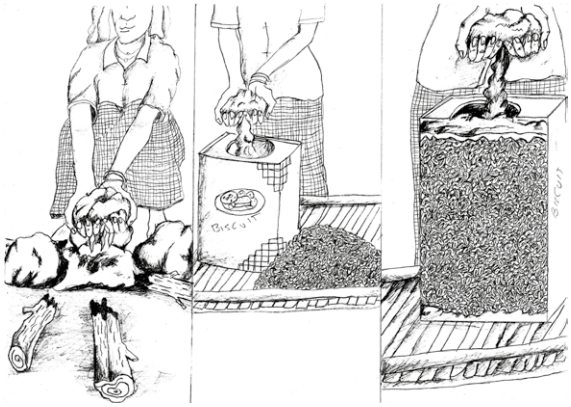
Bamboo and gourds can be made into storage containers. Important: bamboo that is correctly harvested and borer resistant is best (read in Bamboo (**Ch 16**) for details). You can also coat the bamboo in tree resin, coconut oil or wax and then dry it in the sun. This makes the container last much longer. They make great containers but can be affected by mould in the wet season. Clean the bamboo inside with vinegar before it using to reduce mould potential.

Check the stored seeds occasionally to make sure there are no problems.



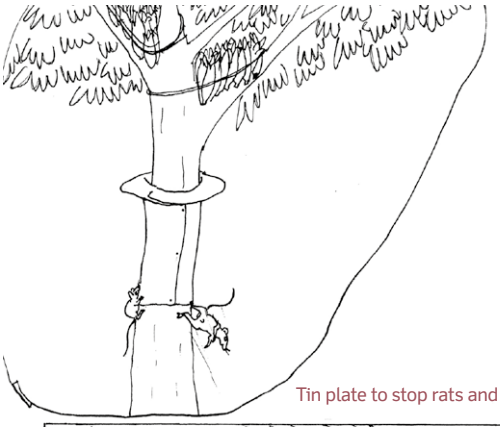
For larger amounts of seeds, biscuit tins, oil containers, and large plastic containers are excellent. Metal drums are also good but are expensive. Grain/Bean Storage Silos, often made by local blacksmiths, are excellent and can be used for large amounts of corn, beans or rice.

Traditional corn storage is a good example of easy, simple, and effective storage from season to season, but it is not good for long-term storage. A tin plate approximately 1m long wrapped around the tree truck will help stop rats and mice. Fold over the top of the tin. Storage containers will reduce the number of seeds eaten by animals.

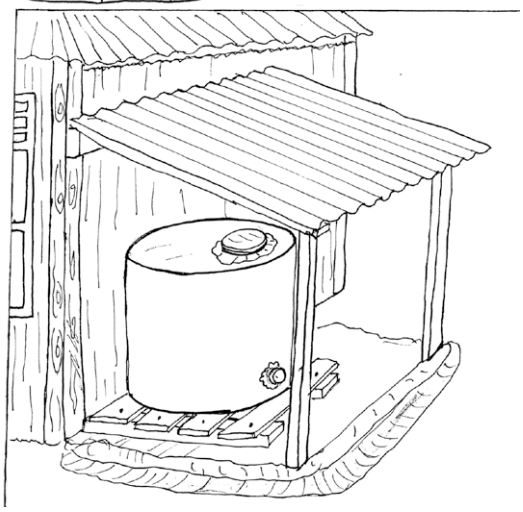


Using ash for seed storage in containers

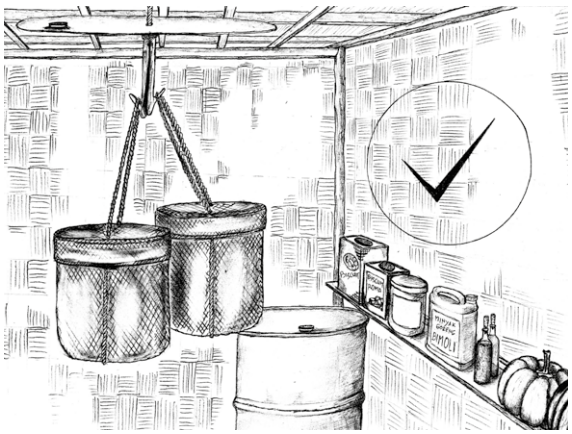
Protecting stored seed from animals



Tin plate to stop rats and mice



Grain/bean storage silo



Protecting stored seed from animals

FRUIT TREE SEEDS STORAGE

Most fruit trees in tropical regions have seeds that don't last a long time. It is best to clean and dry the seed and plant immediately, because the germination rate of the seeds reduces quickly after 2 weeks.

PLANTING MATERIAL STORAGE

Cassava, yams, sweet potato, and taro form a vital part of the food crop in many tropical communities. Arrowroot, lotus, bulrushes, water chestnuts, and Jerusalem artichoke are also eaten a lot. It is the same with spices, such as ginger, galangal, and turmeric.

The best way to store the supply for the next season's crop is to leave it in the ground and use it when you need to. It is important to have high quality tasty stock to use, and grow them so that they cannot cross-pollinate unless you want them to.

If you need to store some roots out of the ground, put them in an animal-proof container that has air holes that are too small for rats and mice to get through. The air holes are essential to let air through and stop the roots from rotting. A fine layer of wood/bamboo fire ash helps to stop insects, mice, and rats from eating the roots.

There are also many important leaf crops that do not produce seeds or are much easier to grow from propagation. Have a variety of high quality plants to take new stock from, e.g. sweet leaf (Sauropus androgynus), some types of water spinach, watercress, tree spinach, gotu kola, Brazilian spinach, and mint.

Garden for supplying planting materials

Step 7: Using the seed and plant material

Now that you have lots of high quality seeds and plant material, you can use them!

Plant some of each variety of saved seeds every season or year, and save the seeds so you have a continuous supply of fresh seeds. Always save some for next year's crop, and keep extra in case of extreme weather or crop failure.

The rest can be exchanged or sold. Good quality local seeds are a valuable commodity. Read in the "Community seed and plant group" section for more ideas on selling and exchanging seeds.

When you exchange or buy new seeds or plant materials, make sure you know the history: where they come from, what micro-climate they grew in, old the seeds are. Seeds or plant materials from very different microclimates can lead to poor production or failure to grow.

If you keep following these steps, you will always have seed and plant material stock and you are improving its quality every year. If you form a community seed and plant group, you will have access to more plant varieties, and have better seed and plant security.

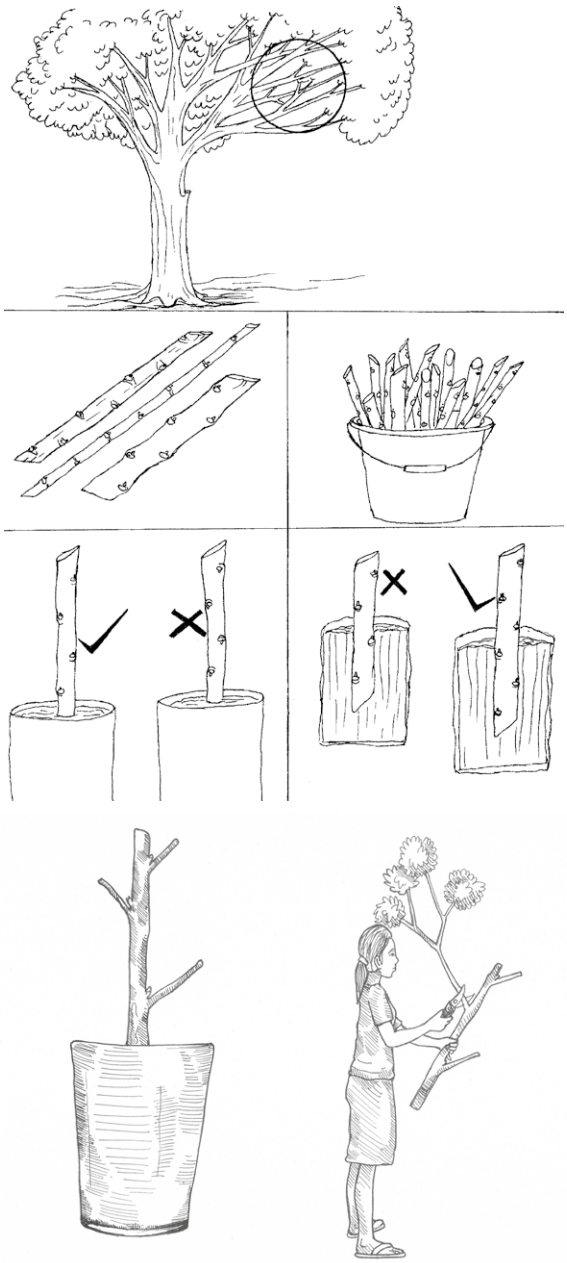
PLANT PROPAGATION TECHNIQUES

Many plants are grown from propagation of plant material not seeds, especially in the tropics. For all propagation techniques (cutting, root stock, marcotting, grafting, and collecting young seedlings) propagate from the healthiest, most productive and disease/pest resistant stock you can find! Propagation will pass on the characteristics of the parent plant, so choose wisely.

TREE PROPAGATION

There are many trees and plants in tropical regions that are easily propagated. Sometimes different plants require slightly different methods, but the following techniques cover the basic methods for good results.

CUTTING PROPAGATION



Step 1: Select the appropriate branches for propagating. The best age of propagating branches is one or two years old. The wood needs to be hard and brown, but not tough and old. For cassava, tree spinach, and other vegetables, the age will be much less, but use stems that are hard rather than green and soft.

Step 2: Cut the ends of the sticks with a sharp knife or secateurs (hand pruners) to make a clean end. Have at least six growing buds on each stick. The growing buds are where the new roots and new leaves will grow from. Cut off ALL the leaves. Cut the TOP of the stick on an angle so that water does not sit on top and cause fungus and disease problems. The growing buds face upwards and will always be above the place where the leaf was.

Step 3: Put the sticks in a bucket of water until ready to plant.

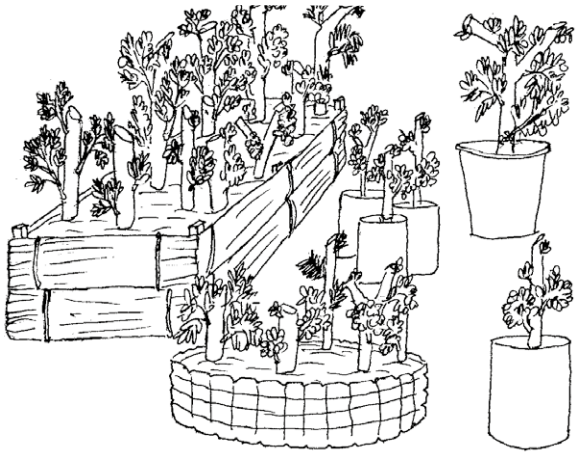
Step 4: To improve the success rate of your propagation, dip the bottom of each stick in a natural root growth promoter before planting, e.g. honey, aloe vera, grated potato, or a mix of these together. This is not essential but it helps, especially in the dry season. Many communities will have their own root growth promoter, or you can have a special bucket of water containing a stick of a plant which grows roots in water quickly and easily. Once that plant has grown roots, the water will contain natural root growth promoter that new sticks can be dipped in before planting.

Step 5: Prepare the planting area. This can be plant boxes or containers in a garden plot or an area of ground. If planting in a nursery, prepare and use the "Cuttings for propagation potting mix" in the Potting mix section of the Plant nurseries chapter (**Ch 12**).

Step 6: Plant the sticks. Make sure that the growing buds face upwards. Make sure that there are three growing buds in the potting mix, and three above the potting mix.

Step 7: Water them every day until the new leaves are growing, then water twice a week. If you are planting out directly into the ground, water the cuttings every day if there is no rain and provide shade until the new leaves are established.

The best time to propagate is at the beginning of the wet season.



MARCOTTING – NEW TREES FROM BRANCHES

Growing trees from a tree branch by creating new root systems is a common practice in many tropical countries.

It is a good method to use because it creates new trees that would take two or three years to grow from seeds. It is most useful for citrus trees but works for many other trees as well. A benefit is that you know how well the tree will produce and a highly productive mother tree will produce highly productive new trees. Be careful because trees grown from marcotting won't grow a main tap root and therefore are more likely to blow over in very strong winds.

Step 1: Choose a strong, productive and disease/pest resistant tree to make the marcott. This is very important because the tree that you grow will have the same characteristics as the tree on which you make the marcott.

Step 2: Choose the branch–about 2cm thick–that you want to use with good healthy growth and where the marcott is mostly in the shade. Cut off about 10cm (the length of the middle finger) of the outside layer of bark from the branch.

Step 3: Cover the cut branch with good quality wet soil (mixed 50/50 with shredded coconut husk if possible) and a little manure, wrapped in two plastic bags. Tie both ends and the middle as well if needed. The two plastic bags help the soil to stay cool.

Step 4: Keep the soil wet and check it regularly, while being careful not to disturb the soil. Leave it for three months.

Step 5: When there are a lot of roots growing you can cut the branch below the marcott. Use a saw if you can because a machete will disturb the roots.

Step 6: Plant the new tree straight away. Carefully remove the wrapping. Put the roots in water until it is planted. Remove about 1/3 of the branches and leaves. Plant it into a pot and place it in a nursery. Keep it in the nursery until new growth commences. When the new tree is established, put it out in the sun to harden. (Read the hardening plants before planting section later in Plant nurseries **Ch 12**). After hardening it can be planted out. (Look in Trees chapter (**Ch 15**) for some tree planting techniques.)

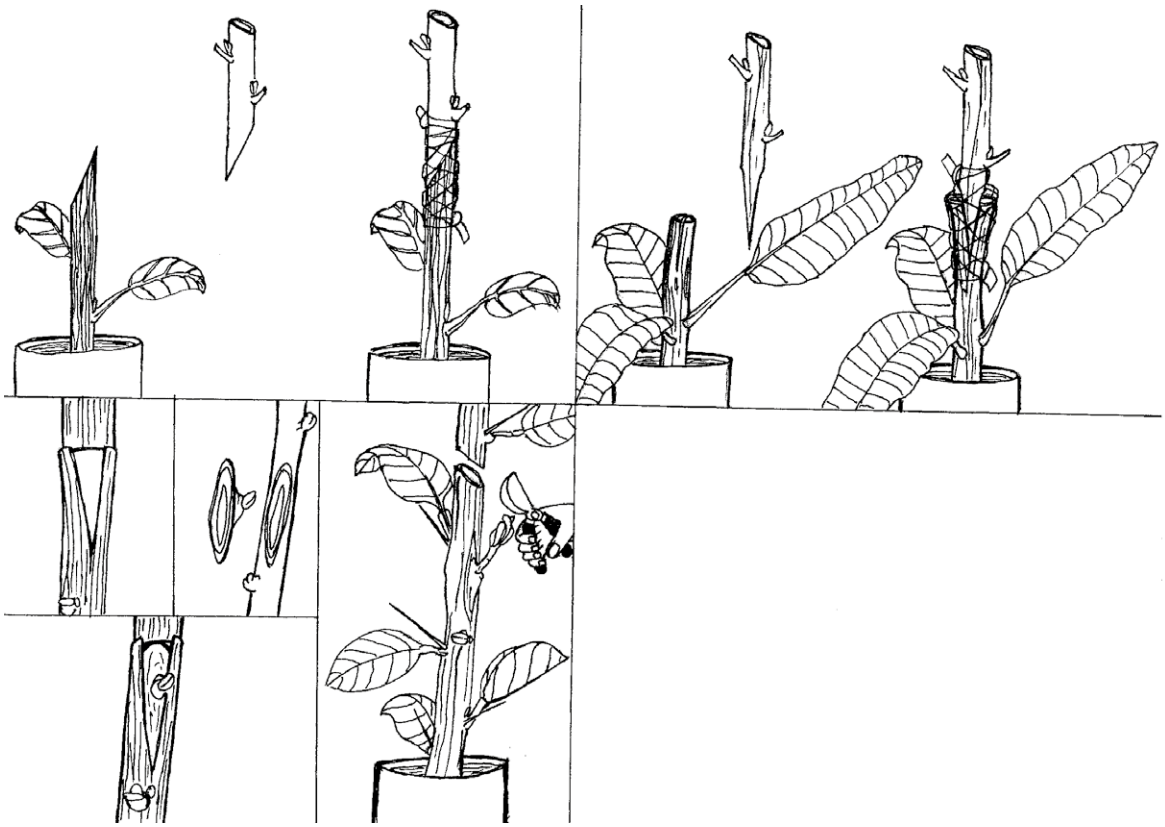
GRAFTING

Grafting is a technique used for fruit and nut trees to improve the quality and productivity of the fruit tree and reduce the time from planting to fruiting. It is a difficult technique that requires practice.

A simple explanation is that a branch from a healthy, good quality fruit tree is "grafted"–attached–to the stem of a small fruit tree (about two years old) of the same type, e.g. mango onto mango, orange onto orange. The branch is stock from highly productive trees with good tasting fruit. The tree it is attached to needs to be strong, tough and disease resistant with good roots.

A full explanation is too long to put in this manual. If you are interested in learning more you can read the references listed at the end of the book, and ask the government agriculture department or local fruit tree experts for more information.

Grafting is a good technique but not essential for producing good quality, highly productive fruit trees. Soil improvement, water storage, organic fertiliser, mulching, and good maintenance are the most important factors for good production. Grafting increases the quality and quantity of fruit and nut production, but only if the other factors are also addressed.



Different grafting techniques

ROOT PROPAGATION

For any plants that are propagated by root cuttings, the following steps will improve the results.

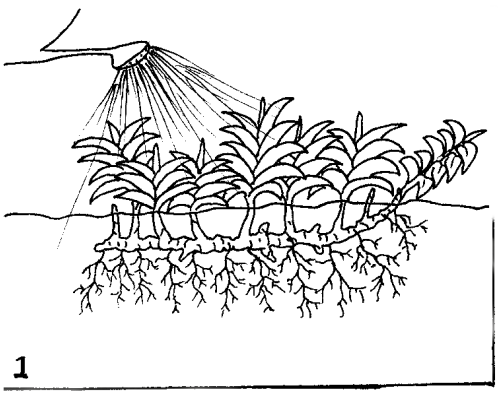
Step 1: Water the plant very well.

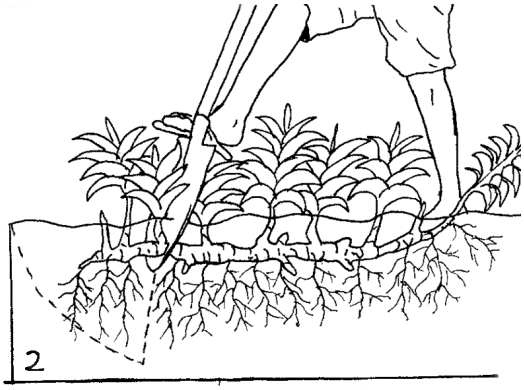
Step 2: Dig into the soil: first straight down through the plant to cut and separate the section of roots that you want to take and; second from the side, digging under the plant and giving room so as not to cut through the root system.

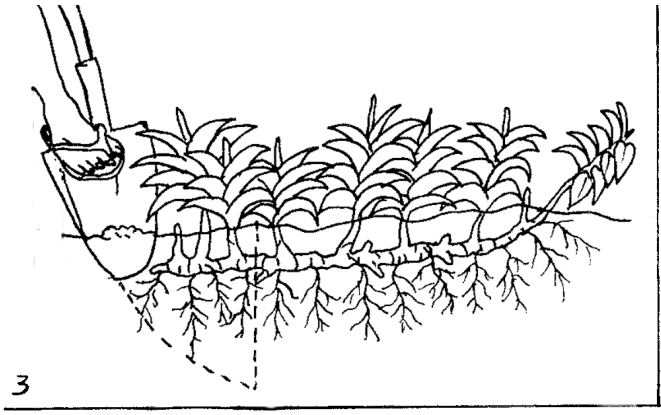
Step 3: Remove the section, lifting from the side and being VERY careful not to damage the roots.

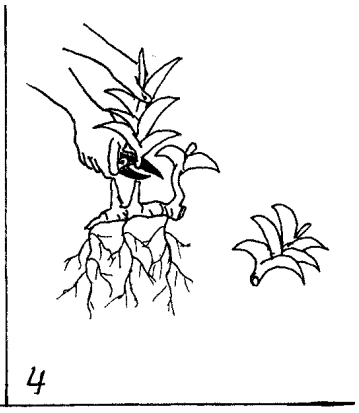
Step 4: Cut off most of the shoots, leaving only one or two new shoots, especially if a lot of roots are damaged.

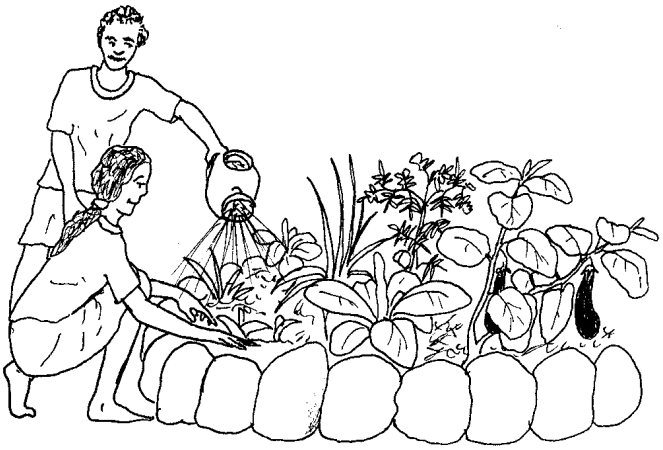
Step 5: Replant it carefully into the ground or into a container and water it well.











5

COLLECTING YOUNG SEEDLINGS

Sometimes the easiest method for growing trees, and even for some vegetables and flowers, is to collect the young seedlings. Young seedling trees can- often be found under large parent trees.

Choose from a strong and healthy parent tree, and collect only the BEST seedlings for replanting; do not collect all of them or the easiest to access. This will help to ensure good quality plants with high production in the future.

Take the seedlings as small as possible – about 5–10cm tall is best. This reduces the stress and root damage caused by removing them. If the seedlings are bigger than 20cm, prune them back to two or three leaves high.

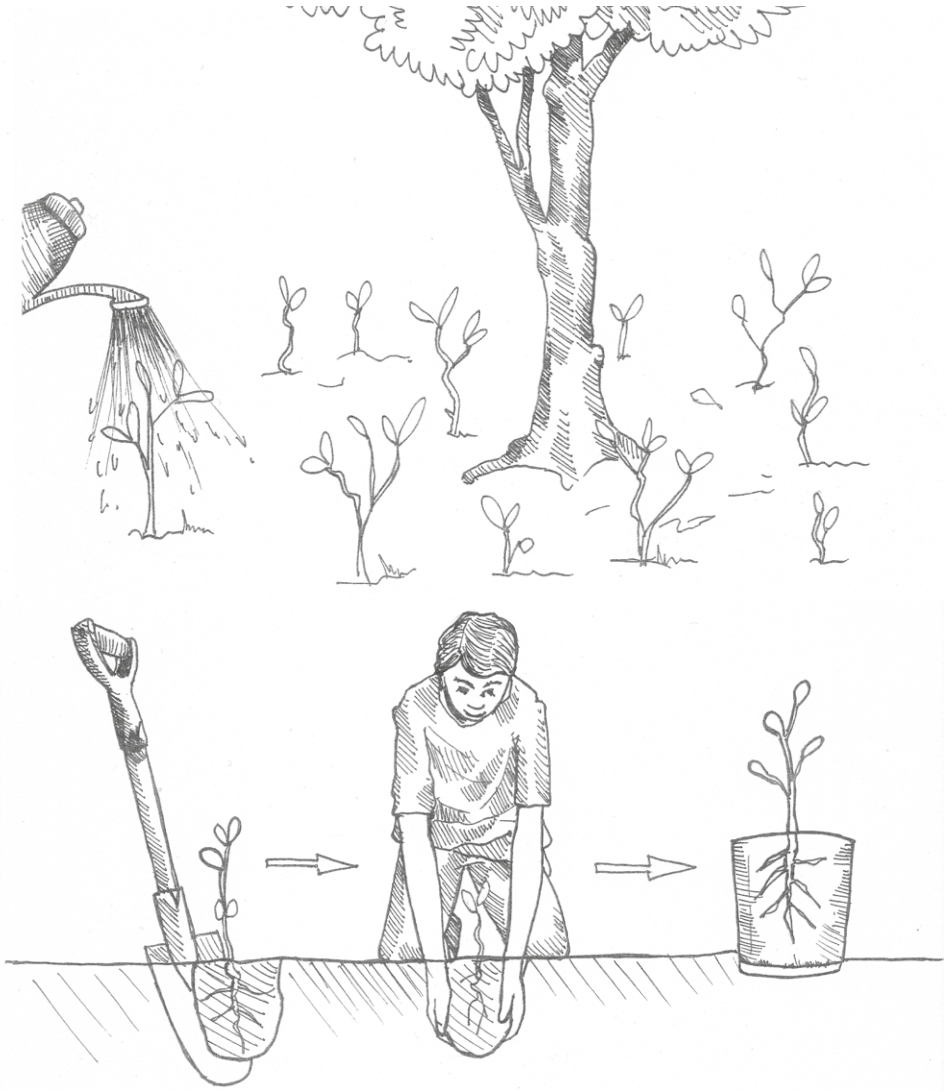
Water the seedlings first or collect the seedlings after rain to reduce root damage and stress. Be very careful and dig them up: DO NOT just pull them out.

Collect a bucket of soil from where you collect the seedlings because it has the right soil micro-organisms for those plants. Add it to the potting mix that you make for the seedlings.

Replant the seedlings into pots, and place them in a shaded area for a week. Then put them in the nursery and treat them the same as the other tree seedlings.

If it is the beginning of the wet season and you want to plant them directly in the ground, give them shade for one week after planting.

For vegetable and flower seedlings, use to same technique, but plant them straight into the ground and give them shade for three days.



COMMUNITY SEED AND PLANT GROUP

A community seed saving and plant group is an excellent way to share excess seeds and increase the variety of seeds and plants available to everyone in the community. Community seed saving and plant groups also buy, sell or trade with other areas to bring in new plant varieties.

Plants, such as bamboo, bananas, yams, arrowroot, sweet potatoes, potatoes, cassava, taro, lotus, Jerusalem artichokes, sweet leaf, gotu kola, Brazilian spinach, tree spinach, water cress, water spinach and many more, provide planting material for new plants and crops.

A community seed saving and plant group is like starting a bank for seeds and planting material. The group collects and stores the best seeds and planting material, which are saved for growing, exchanging or selling in the future. The whole process of choosing, collecting, drying, storing, and distributing seeds is a lot easier as a community group. A garden can be set up to grow high quality plants for distributing plant materials. It also speeds up the process of improving seed and plant quality and, therefore, improves crops. Look in the Cooperatives chapter (**Ch 5**) for ideas on how to set up a community group. There are many functions that a community seed saving and plant group can provide.

Community seed garden, storage room, nursery and shop

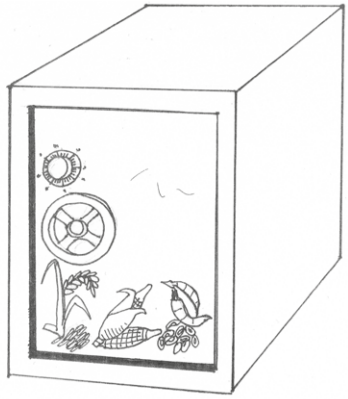
1. SEED AND PLANT EXCHANGE

It can start as a way for people to bring in their extra seed or plant material and exchange it with other people who have something different. This increases the variety of plants that people can grow.

2. SEED AND PLANT BANK

SEED BANK

A seed bank is a special seed supply that is stored in case of emergencies, such as crop failure, floods, drought or large storms. It is not part of your seed exchange or regular seed supply. It must be replenished with fresh seed stock each year and must hold a good selection of each of the staple crops in your community. Store as much as your community group can spare.



PLANT BANK

Plant material is taken from living plant stock. Therefore a garden is needed to grow the material for the bank. Choose high quality material and a few varieties of each plant, but plant them far enough apart so they cannot cross-pollinate. Make sure that there is always plant stock for members, especially for emergencies.

3. SEED AND PLANT SELECTION

Collect the seeds from the healthiest, most disease resistant crops in the community. Choosing two or three crops is best. Only 5–10 % of the crop needs to be left for seeds. The families that grow the crops from which seeds are collected can be compensated by selling to or trading the seeds with the group. The trading could include labour, time, etc.

As well as improving the seed stock for the group, it is important to find out why the crop grew well, e.g. good soil, pest predators, amount of water or sun, terracing, etc. The same selection techniques are used to improve planting material quality as well.

4. SEED COLLECTING AND DRYING

Seed collecting and drying is much easier and quicker when working with a community group. This is especially for collecting tree and plant seeds and propagation material from community land, native vegetation or forests.

5. SEED DRYING ROOM

A seed drying room provides a space for drying large amounts of seeds, especially in the wet season. It protects seeds from the rain and animals. Good ventilation is very important to protect seeds from too much moisture.

6. SEED STORAGE

A community hall or allocated house can be used for seed storage. Seed storage is quicker and easier when done by many people at once. Buying or collecting storage containers for large amounts of seeds is much easier and cheaper when bought by a community group. Seed storage silos are an excellent example and designed to prevent pest and insect damage. Large plastic containers and biscuit tins are also good for most types of small seeds.

7. SEED AND PLANT SUPPLY

All seed and plant supplies must be used wisely. The seeds should be distributed evenly among group members so that each member has enough for their own land. This includes community land. If the amounts vary a lot, other exchanges could be worked out. It is always good to keep enough seeds for one more crop, in case of problems. The plant material supply will not usually be enough for all the land, but it is a source of good stock for members and can be kept for emergencies. All members who receive seeds and plants need to provide something to the group as well. This could be producing the seeds, working at the plant bank, labour, manure, compost, land, storage containers, etc. If there are still seeds and plants remaining after distribution, they can be used for trading and selling.

8. SEED AND PLANT MATERIAL GARDEN

A community garden just for producing seeds and plant materials benefits the whole community, providing good quality seeds and plants for people to grow. It also makes it easier to reduce unwanted cross-pollination and to pick from the best plants.

9. SEED AND PLANTING MATERIAL LIST

A list of plants, seeds, and planting materials helps to show people in the group what is available to grow. It also provides a list for people in other communities and groups of what is available for buying or trading.

Important information that is included:

A. Name: local name, national language name, botanical name (if possible).

B. Plant description: how it is used.

C. Plant size and shape.

D. Time to fruiting: how long after planting the seed does the plant produce fruit or leaves?

E. Amount produced by each plant: large, medium or small.

F. Eating quality: is the variety of plant considered good to eat?

G. Does the plant have other uses, e.g. medicine, building material?

H. Insect and disease resistance.

If there are two or more types of the same plant (e.g. tomato) then write these separately as different plants with different names, e.g. round red tomato and bell shaped yellow tomato. This is because the different types will have different yields, different disease and insect resistance, and different time for fruiting, and even different eating quality.

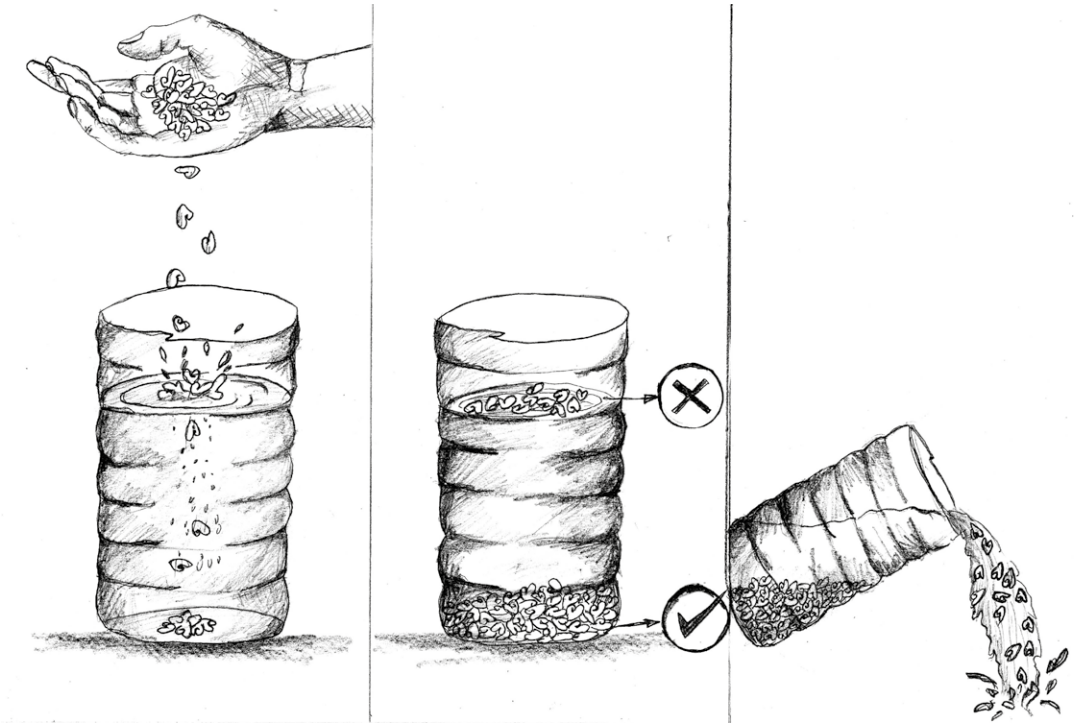
Other benefits of a list include:

- Helps to identify the best place to grow each type of plant
- Identifies differences in types of plants
- Can be combined with other plant lists to form a regional or national plant list
- Helps to assess what a community can produce and what needs to be introduced
- Helps to keep local plant types locally owned

10. SEED TESTING

Seeds can be tested to find out how many will grow. There are two good methods for testing seeds:

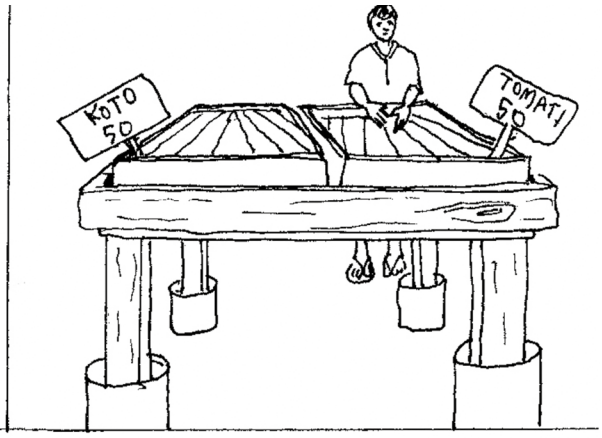
1. **For growing your own crops:** place the seed in a container of water. The seeds that sink are good and can be planted. The seeds that float at the top are no good and can be thrown away. Most of the seeds will usually sink.



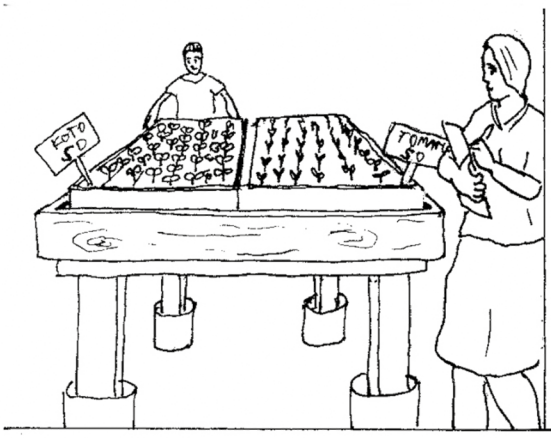
2. **For selling and trading seeds:** seeds that are sold or traded need to be tested first to find out their viability rate. That is the percentage of the seeds that will germinate and grow. The viability rate is then written on the packets. There are different methods to do this. The basic idea is to count a number of seeds (e.g. 50 bean seeds), then plant the seeds and find out how many grow (e.g. 40 bean seeds grow). The number that grows is divided by the number that you planted, to find the percentage of beans that grow. (40 divided by 50 equals 0.8. Then multiply by 100 to find the percentage: 80%.) This is the viability rate (80%).

Seed testing for trading and selling seed

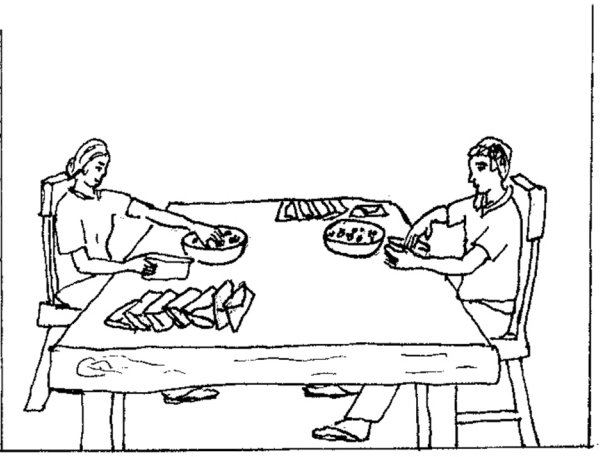
Counting seed



Planting seed



Counting seedlings



Packing and labelling seedlings

It is very important that you:

- Use a good quality potting mix.
- Water the seeds every day.
- Prevent insect attack, e.g. snails, slugs or ants.
- Continue the test until the seeds stop germinating.

When finished, plant the seedlings in the vegetable garden.

SMART IDEA:

Seed testing can be used to check viability rates of seed after six months, one year, eighteen months, two years, three years, etc.

More information about seed testing is in the reference chapter.

11. EXCHANGING AND SELLING SEEDS AND PLANT MATERIALS

Seeds can be packaged and exchanged or sold in the community or to other communities, towns, and regions. Within communities seeds are exchanged, traded or sold as needed. Selling to or trading with other communities or groups requires a continuous supply of seeds. It also requires a marketing campaign to advertise your seeds so that people know they can buy them from you. A community group seed garden will help to increase seed supply. Seeds must be tested first to make sure they are good quality before they are sold or exchanged.

Plant materials can also be exchanged or sold. Crops from these plants are improved by selecting the best producing, most disease resistant plants from which to take new plants.

Trading types of bamboo

12. COMMUNITY NURSERY

The next step is to make a community nursery where vegetables, fruit trees, and other plants and trees can be grown, and that is the subject of the next chapter!

RESPONSIBLE SEED AND PLANT USE

It is great to introduce new seeds and plants to a place, especially if they are very productive, but be VERY CAREFUL not to introduce new pests and diseases as well! Spreading diseases or pests creates big problems and can destroy crops. Some plants have the potential to become problem weeds that can do more harm than good.

DO NOT INTRODUCE NEW PESTS OR DISEASES

1. From one region to another.

- Check seeds for insects and insect eggs. Remove seedpods and any plant materials. Wash large seeds well and re-dry. Coat seeds with a fine layer of wood fire ash to help stop further insect problems. Mixing dried, crushed natural pesticide leaves with the seeds will also help to kill insects or eggs.
- Check plants to make sure they do not have any pests, virus, fungus, mould or other diseases. If they do, do not move them!

- Do not move any soil from one area to another if it has fungus, nematodes or other diseases.
  If you want to move root stock from one region to another:
  A. Clean off all the soil thoroughly from the root stock.
  B. Wash it very well.
  C. Leave it in the open air for an hour or two (oxygen kills a lot of bacteria), but do not put it in direct sunlight which damages the roots.
  D. Wrap it in wet newspaper or wet old cloth for transport.

Cleaning root stock before transport

2. From overseas. Please follow your country's quarantine regulations and take responsibility to ensure that new pests or diseases are not introduced.

RESEARCH ANY POTENTIAL WEED PROBLEMS

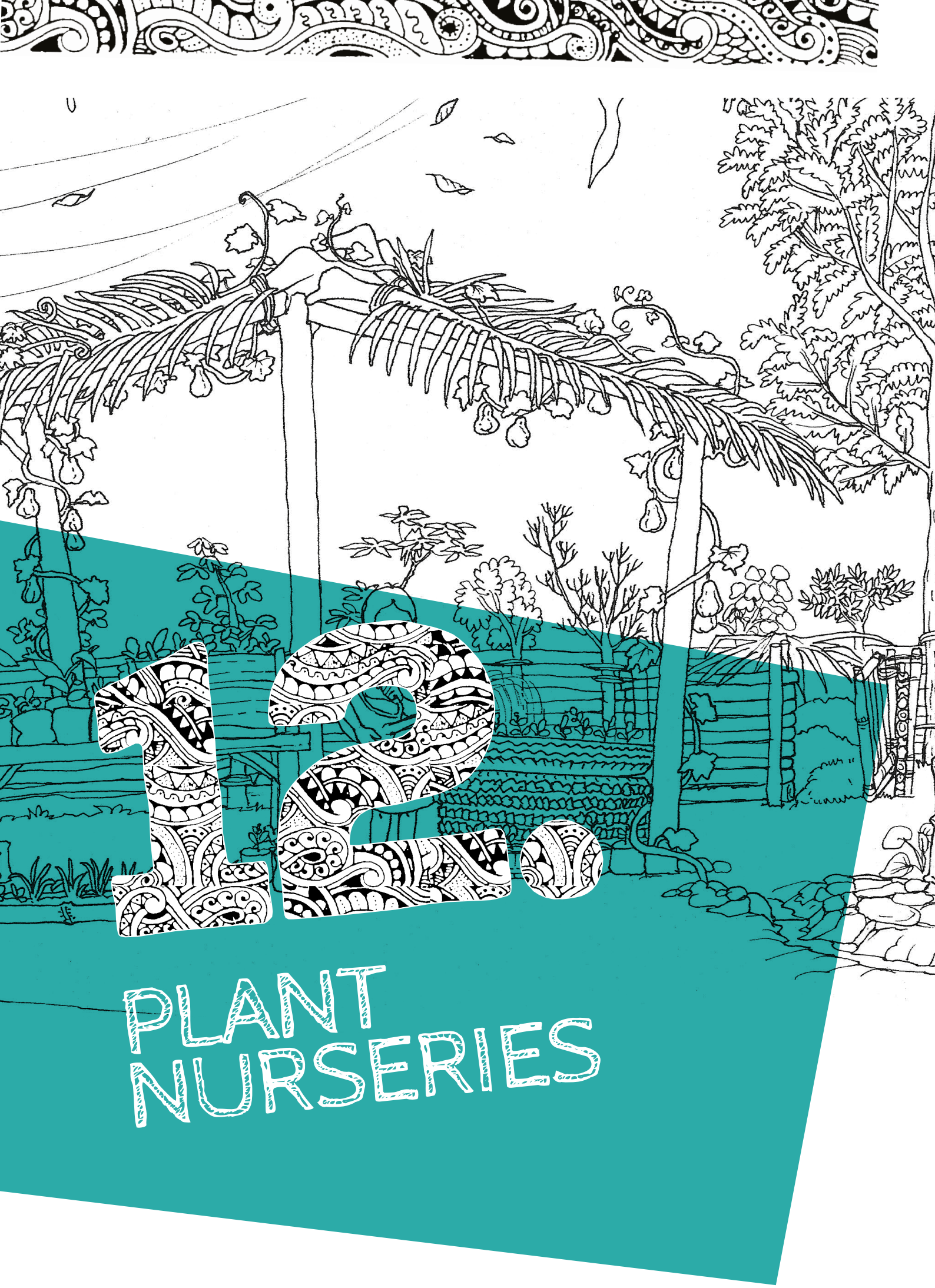
Any new plant or tree that is introduced could become a problem in the future. Plants could spread and become weeds, disrupting local environments. This can happen with all types of plants, and even very productive trees and plants can become problems. Rivers and water catchments are usually the worst affected.

Research any new plants to find out:

- What their growing habits are
- If they spread naturally, e.g. birds or animals eating and spreading seeds
- Whether they have caused problems in other places
- If they suffer from diseases that could spread in a new place

This is very important for protecting the environment and resources for the future.

SEEDS AND PROPAGATION
CHAPTER NOTES



12

PLANT NURSERIES

12. PLANT NURSERIES

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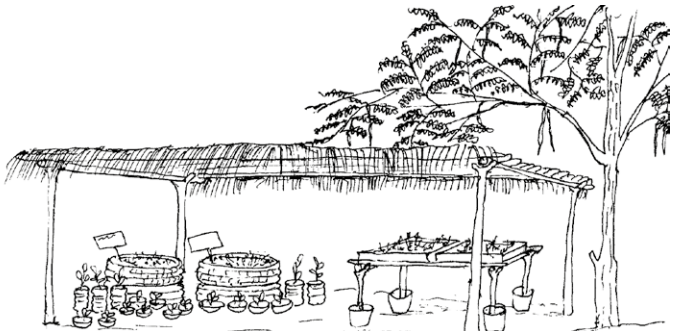
A plant nursery is an essential part of every farm and garden. It provides the best environment for plants when they are small and fragile. As children need special attention when they are young, so do plants. Healthy, strong seedlings grow into healthy, productive plants.

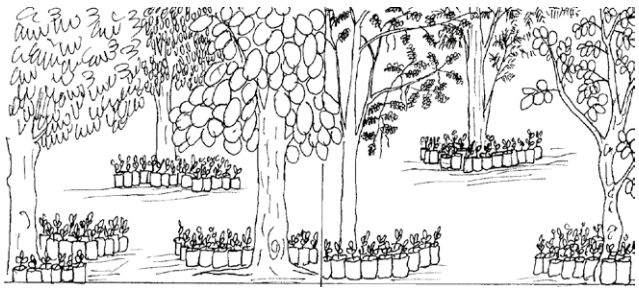
PLANT NURSERY

The early stages of a plant's life determine how well it will grow in the future. This is the same for all plants grown from seeds, cuttings, roots, and other methods of growing plants. A nursery can be as small or large as you need: e.g. it can be part of a garden bed with some coconut leaf cover or a large community nursery for growing reforestation and plantation trees. Small nurseries can be used to grow vegetable seedlings as well as plants, flowers, fruit trees, shade trees for animals and other trees.

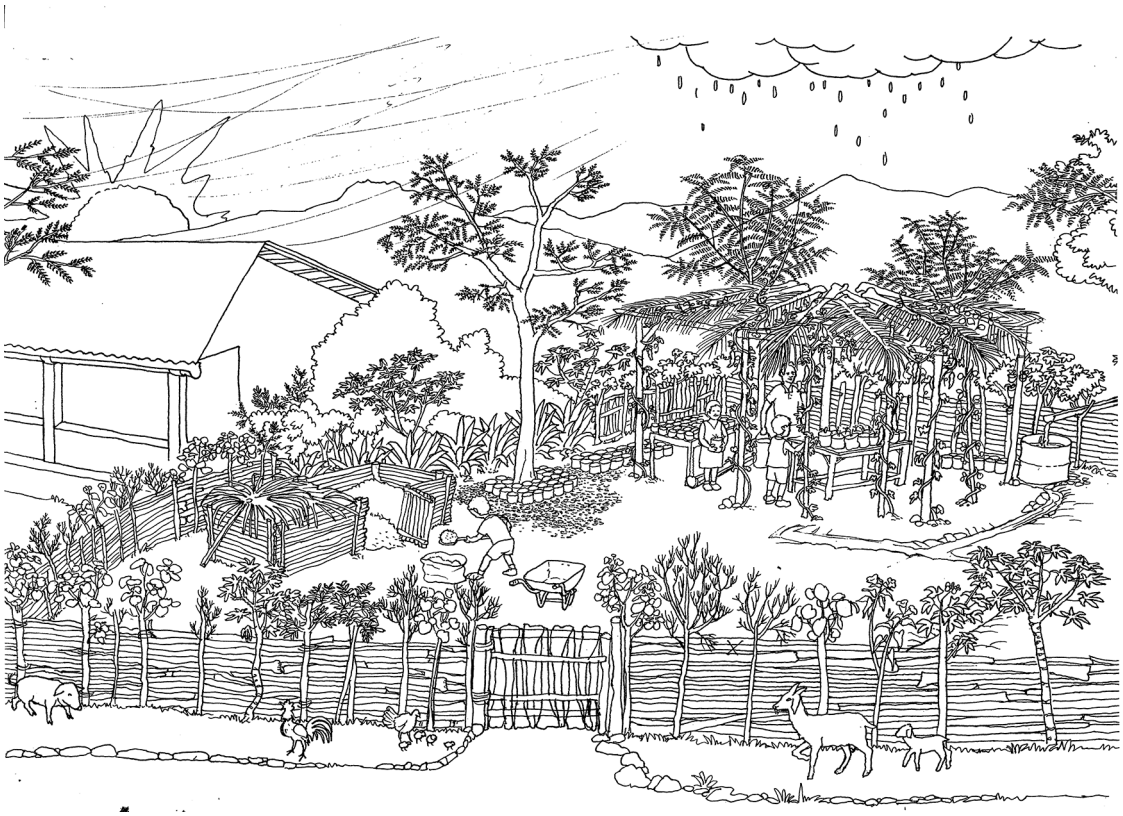
Important functions that nurseries provide:

- Easier planting, watering and maintaining seedlings because everything you need is in one place
- Shade from the hot sun
- Protection from heavy rains
- Protection from strong winds
- Protection from pests, such as rats, mice, goats, snails, and ants
- Water and fertiliser can be easily applied and checked
- Potting mix allows for fast and strong root growth, good drainage, and supplies enough nutrients
- Potting area including a table





In this section we explain all the steps necessary to create a good nursery.



NURSERY LOCATION:

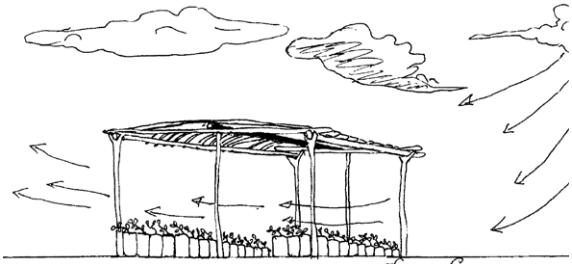
The nursery is the heart of the garden and requires daily attention. Locate it close to the house and/or close to the garden. A nursery requires water on most days, so it needs to be located close to a water supply.

Trees can be used to give shade to the nursery. However, too much shade will cause problems later on because the seedlings will be weak. Good shade trees for nurseries, such as sesbania, albizia, and eucalypts, will allow some sunlight through. Trees, such as mango and avocado, give too much shade.

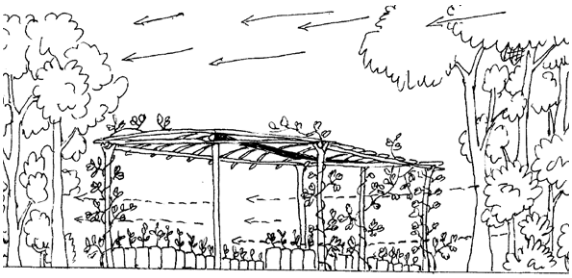
The best situation will allow morning sunlight and provide shade during the middle of the day and mid afternoon when the sun is hottest. Some gentle wind is good for the plants, but exposure to strong winds will slow growth.

Windbreak protection from strong winds will be needed. Trees can be used as long as they do not shade the nursery. Smaller trees, such as bananas, are great. Walls around the nursery made from vines, palm leaves or palm leaf stalks also help protect the small plants.

Small to medium trees around the nursery help to keep the air moist and create a good microclimate for growing healthy seedlings.



No protection



Good protection

NURSERY DESIGN AND CONSTRUCTION

Every nursery constructed will be different according to needs, land and constructions materials.

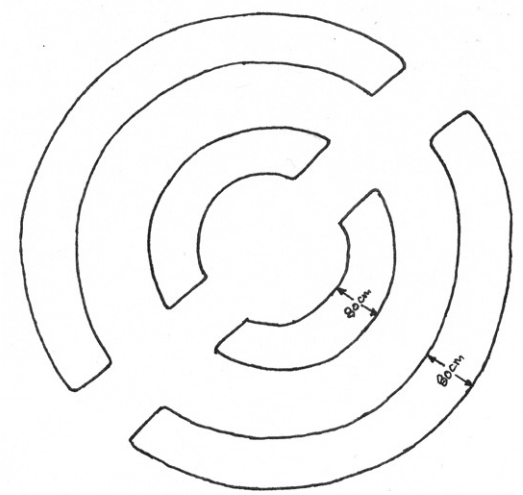
You can use the examples that we show or create your own design. Make the nursery as long lasting as possible. Nurseries should have areas with different amounts of sunlight: it is good to have three different areas.

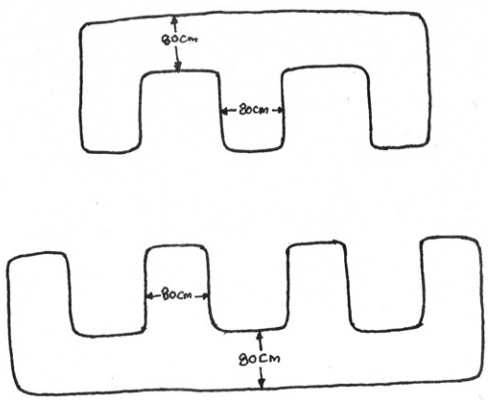
Area 1: Small seedlings and delicate plants need good protection from the hot sun and from heavy rains.

Area 2: Larger seedlings need less protection and benefit from more sunlight.

Area 3: Have an area that allows full sun. This is for seedlings to "harden" before they are planted in the ground. To "harden" a plant is to prepare it for the conditions in which it will grow. Large tree seedlings need three to four weeks to harden, and vegetable seedlings need one week to harden before planting.

Nursery shape: The nursery design can be many different shapes. Choose the right shape to suit the land and your needs. Focus on the shape making the nursery work well with maintenance as easy as possible.



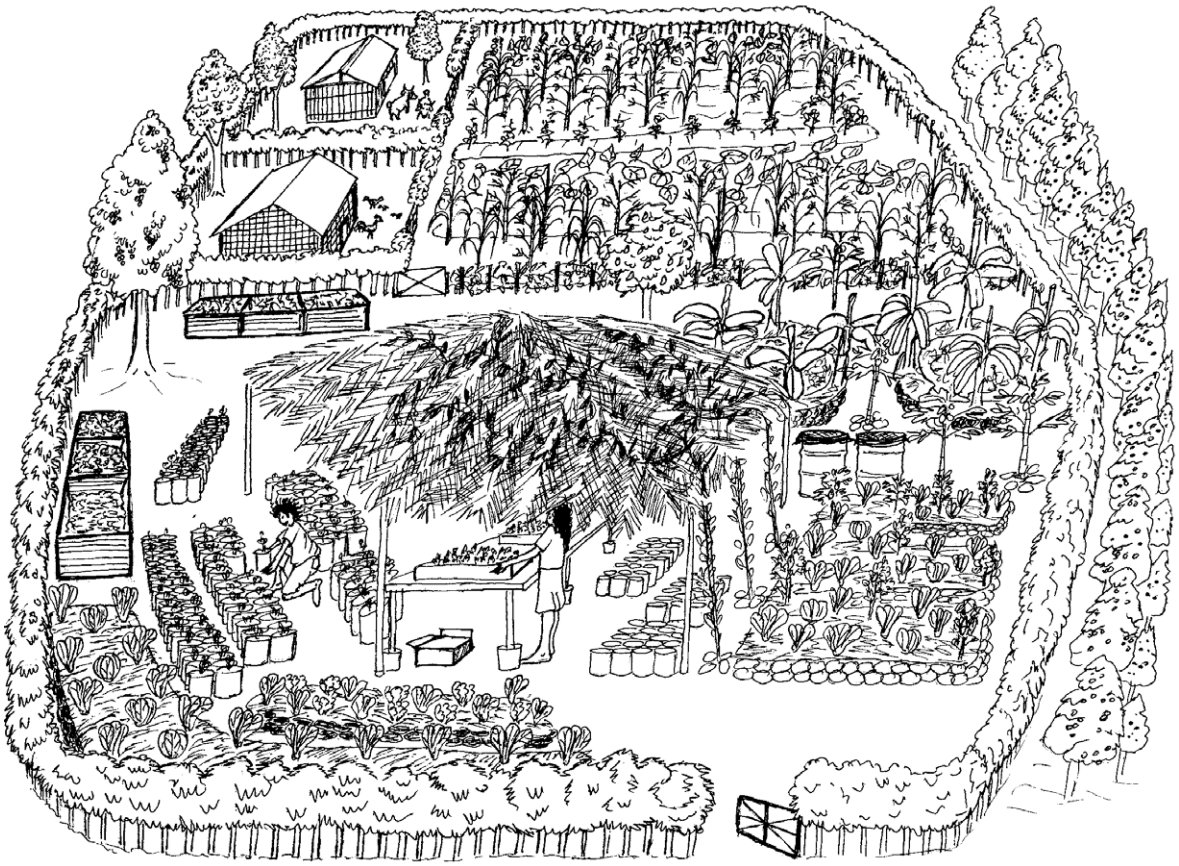


When designing and building a nursery, it is good to leave room for future nursery growth.

All nurseries need to provide protection from animals. Nursery tables that are waist high are easier to manage, provide animal and pest protection, and other benefits.

Larger nurseries are much easier to build and maintain if a group of people is involved. This could be family, neighbours, a community group, school or church. Everybody involved will benefit more from the work that they do and costs will be lower. Different people can choose to work in different areas in the nursery, or everything can be grown together and divided up when it is ready to plant, or a combination of both. Larger community and school nurseries are important for growing trees for reforestation work, and growing fruit trees and vegetables for family and school gardens.

Protect your plants from goats and other animals



Nursery with vegetable gardens, vines, animals, living fences, windbreaks and composts

NURSERIES CAN ALSO BE MULTIFUNCTIONAL

- Grow vines, such as luffa, cucumbers, beans, and gourds, on the structure and the fences. They provide food as well as wind protection, and improve the nursery microclimate with increased humidity.
- The nursery can also be the liquid compost/compost-making area for the garden.
- It can be used for seed drying in the dry season.
- Move the excess water and nutrients from the nursery to vegetable gardens or to small fruit trees and vines. The edge around the nursery is a very productive area and should always be used.

GOOD MATERIALS TO USE FOR CONSTRUCTION

Hard wood poles are good for the main frame because they are long lasting: e.g. eucalyptus, teak, ironwood, mahogany, coconut. Each region has its own hardwoods. Choose hardwoods that are common, not endangered and from plantations, not natural forest.

Bamboo can be used for poles, and are much more sustainable and easy to grow than hardwood. Some types of bamboo are borer resistant, but others will be eaten in one to two years. Correctly chosen, harvested and treated, bamboo will last for many years. Read Bamboo (**Ch 16**) for details.

SMART IDEA:

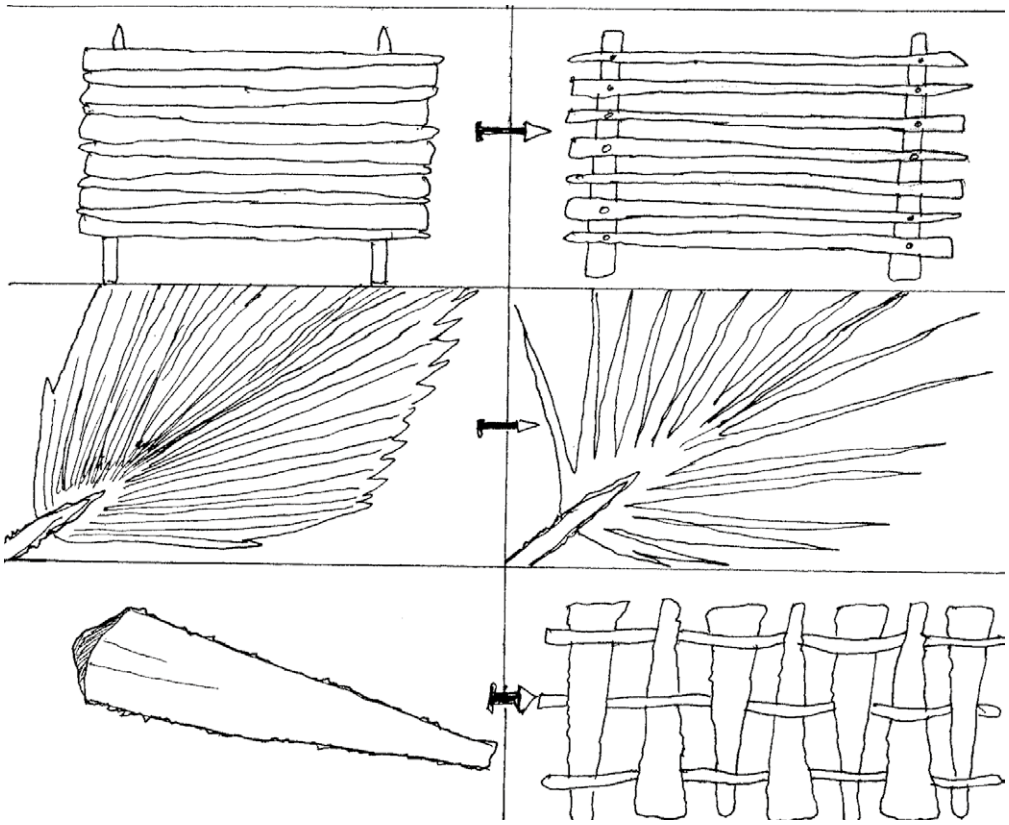
Plant hardwood trees for the future: plant more that you will use. They are valuable and can provide income.

Roofing materials can be:

A. Panels of split palm leaf stalks
B. Split bamboo
C. Coconut leaves
D. Grasses tied up in bundles. Make a thin cover so that some sun can come through.
E. Split palm leaves
F. Cane grass

Fence/wall/frame materials can be:

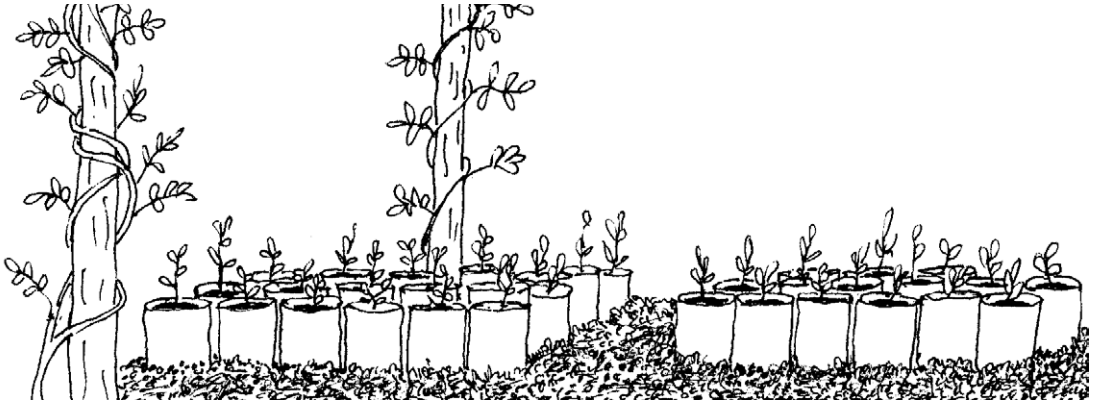
A. Living fence e.g. gliricidia, leuceana, moringa
B. Bamboo, split bamboo or wooden poles
C. Palm leaf stakes
D. Panels of palm leaf stalks
E. Cane grass
F. Whatever else you can find that will keep animals out!



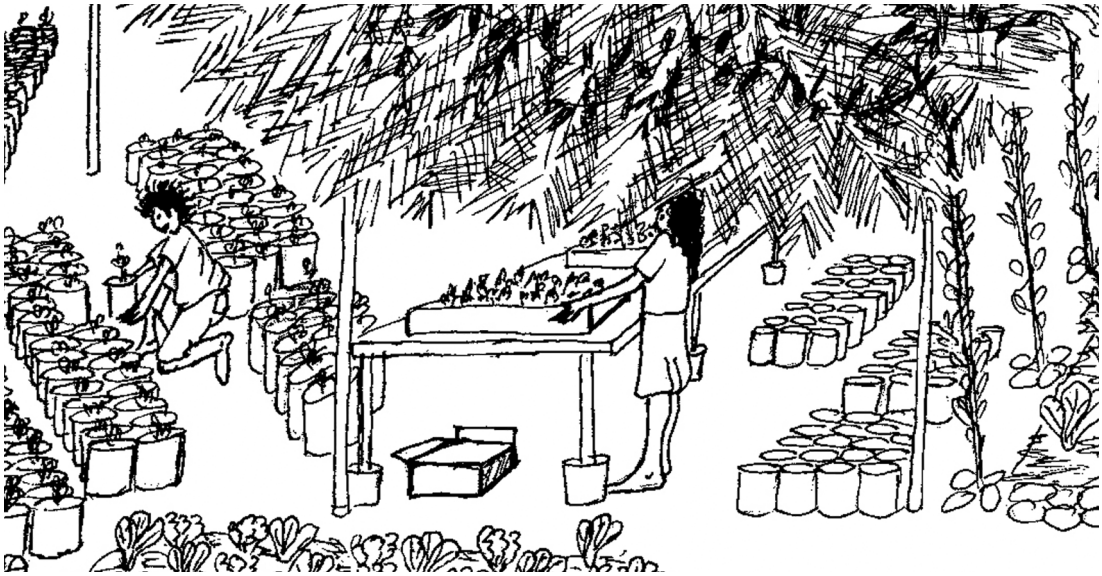
NURSERY TABLES AND WORKBENCHES

There are many benefits to having the seeds and seedlings raised off the ground:

- All the nursery work of preparing, planting and maintenance is much easier.
- Your back will be much less sore! Remember – think smart!
- It is easier to observe the seedlings' health and pest damage.
- Prevent pests like snails, slugs and ants.
- Prevent roots growing out of the pot and into the ground. This creates big problems later on.
- Prevent weeds in the ground becoming a problem.
- Pots, potting mix, tools and other equipment can be stored underneath.
- In mountain areas, seedlings grow better and do not get damaged by frosts and cold air if they are raised off the ground. Waist height is best. At night the air temperature is coldest on the ground and less cold at waist height. Other plants and trees nearby also reduce cold temperature problems. A thick cover (10-15cm) of rice or coffee husks on the ground also helps. However, a layer of rice or coffee husks could promote fungus problems in hot areas.



Coffee husks covering the ground



Nursery workbench with protection from ants, snails, and slugs

Table/workbench materials can be:

A. Old tables

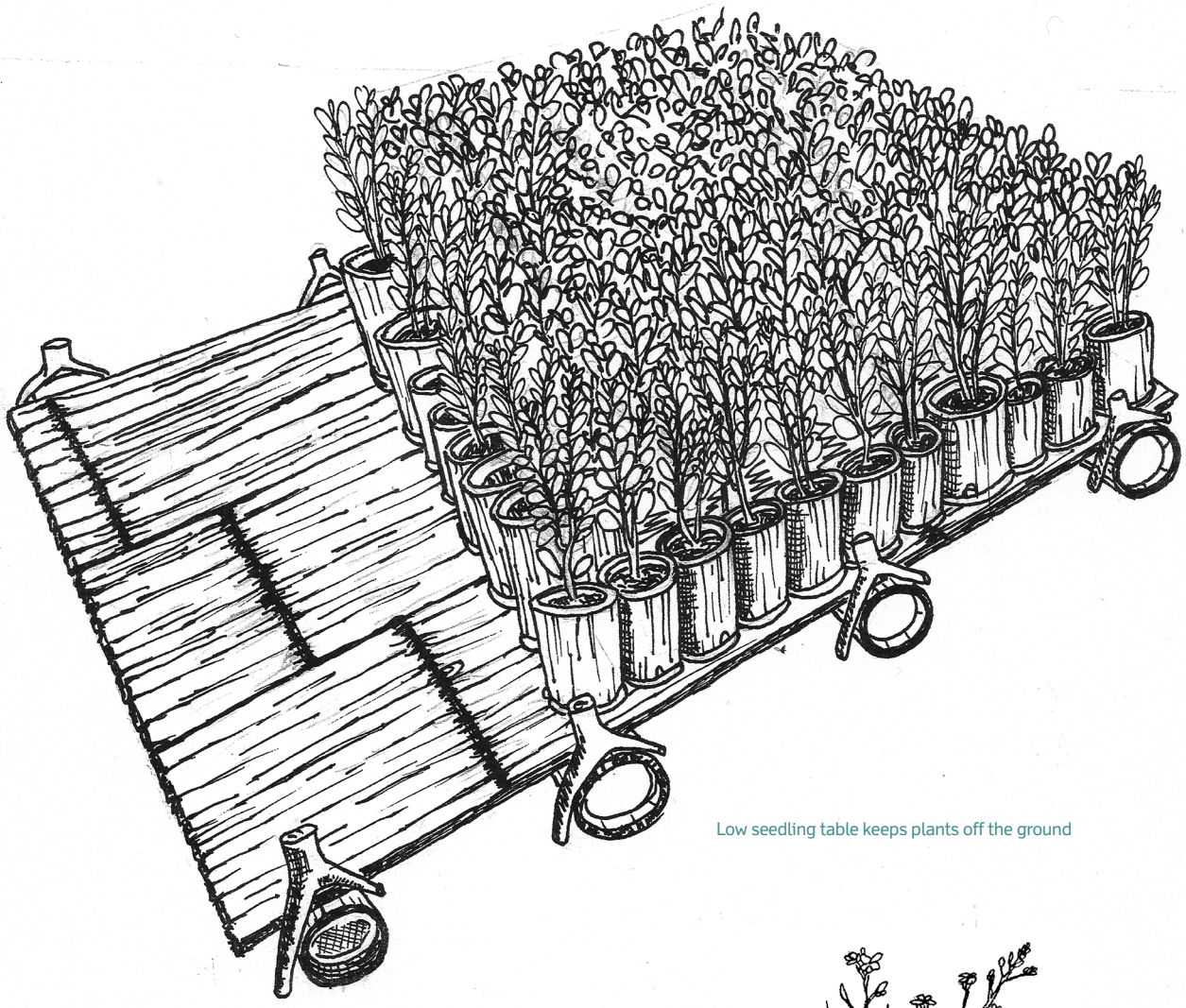
B. Bamboo

C. Wood

D. Palm leaf stalks

E. Anything that is suitable

For large nurseries and many situations, having tables and workbenches for all your plants is not possible. However, even one or two tables for your most fragile seedlings will help improve success rates a lot.

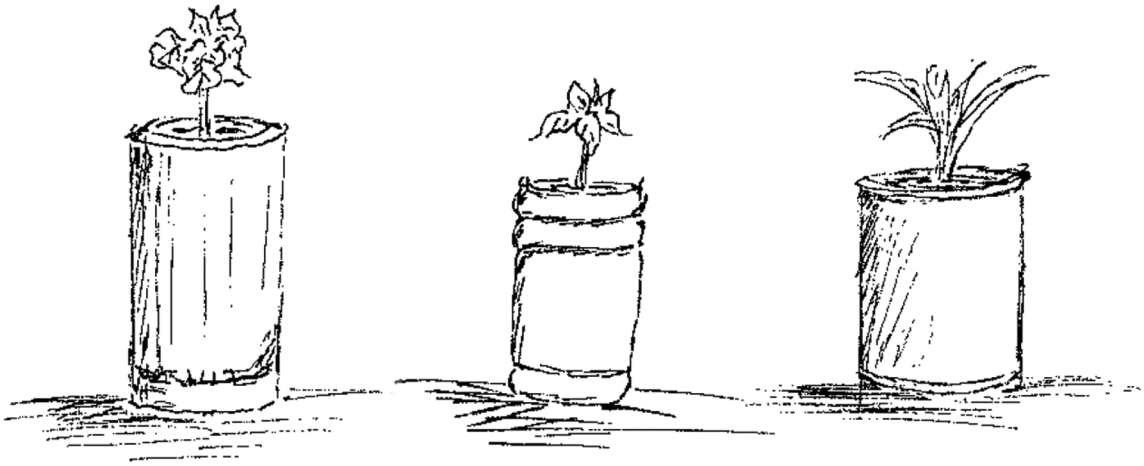


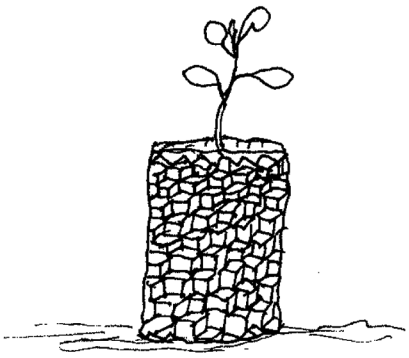
Low seedling table keeps plants off the ground

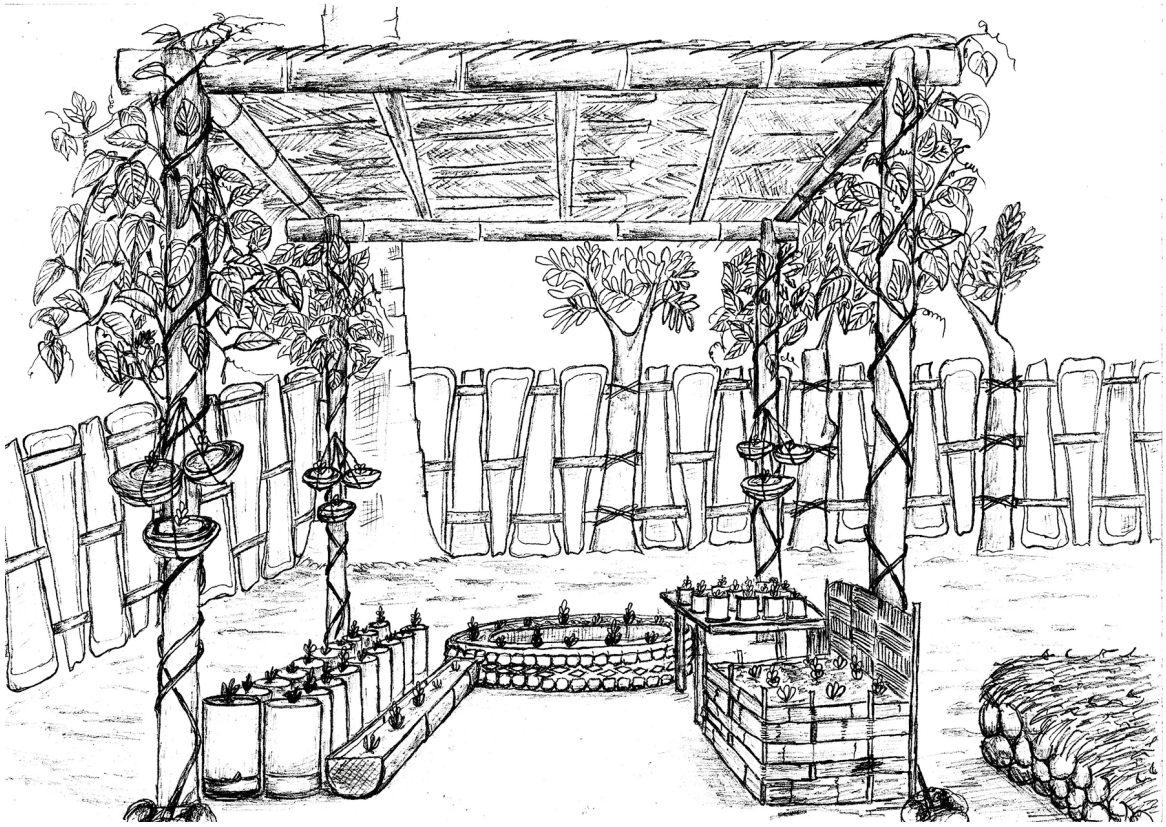
SEEDLING BOXES AND CONTAINERS

Seedling boxes and containers need to be deep enough for roots to grow long and not grow around in circles. This is especially important for tree seedlings, and it also makes transplanting much easier. Seedling boxes are easy to make, and they are good for growing many vegetable seedlings at once.

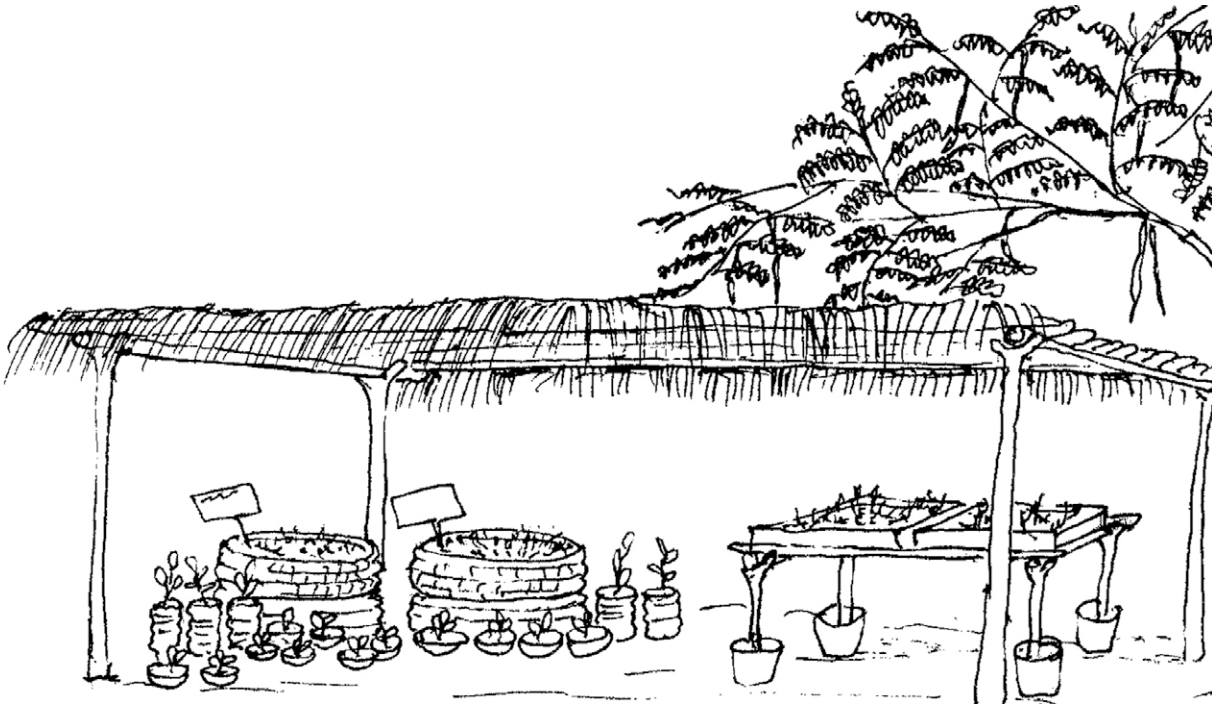
They are also good for planting tree and plant seeds, which are then planted into separate containers when they are about one month old or have four sets of leaves. Height and good drainage are important. Choose the size of the boxes to suit your needs and the materials you have. They can be made from any wood, old or new, including bamboo. If you use bamboo, place the bamboo skin on the inside of the container to give better water drainage and help it last longer.







Various seedling and plant containers

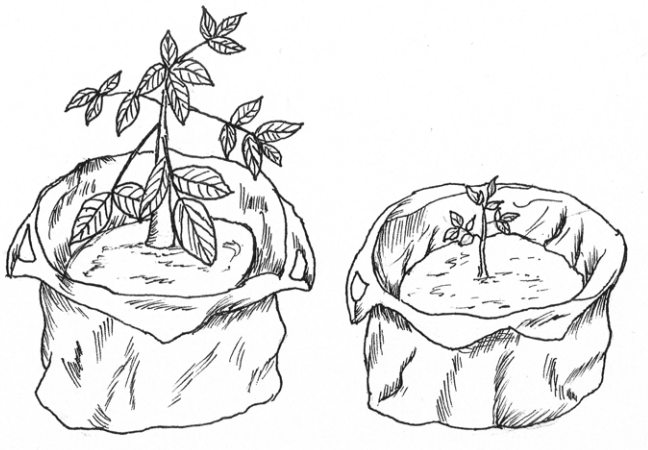


DIFFERENT CONTAINERS

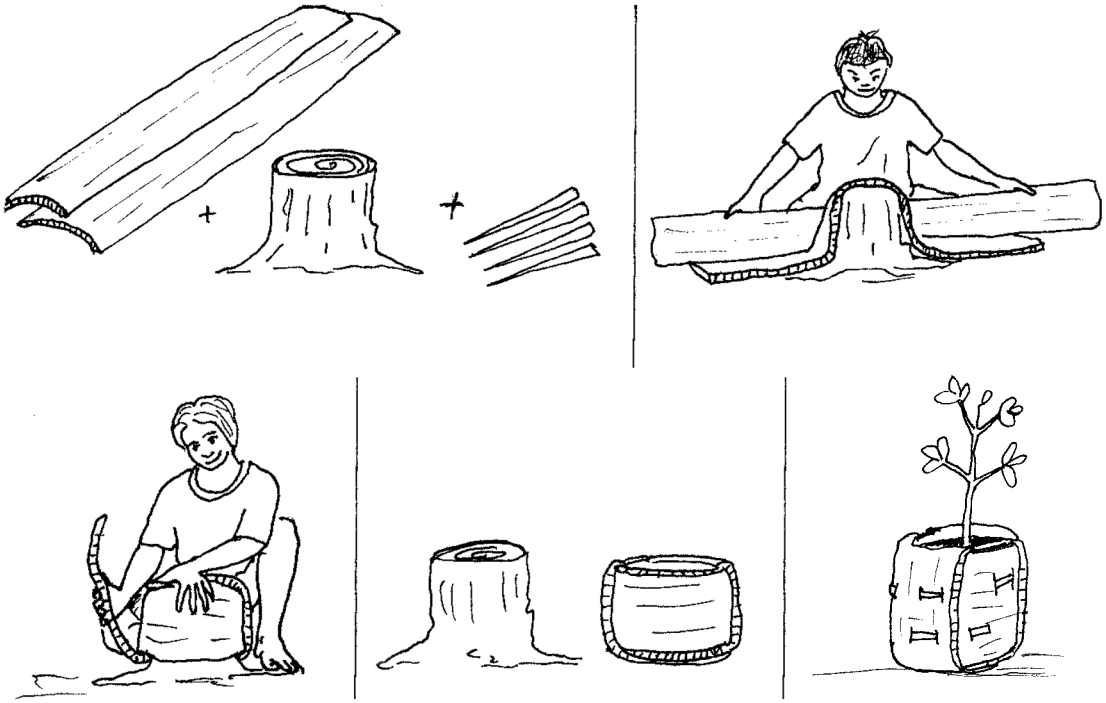
Many different containers and natural materials can be used for seedling and plant containers.

All seedling containers must have drainage holes at the bottom:

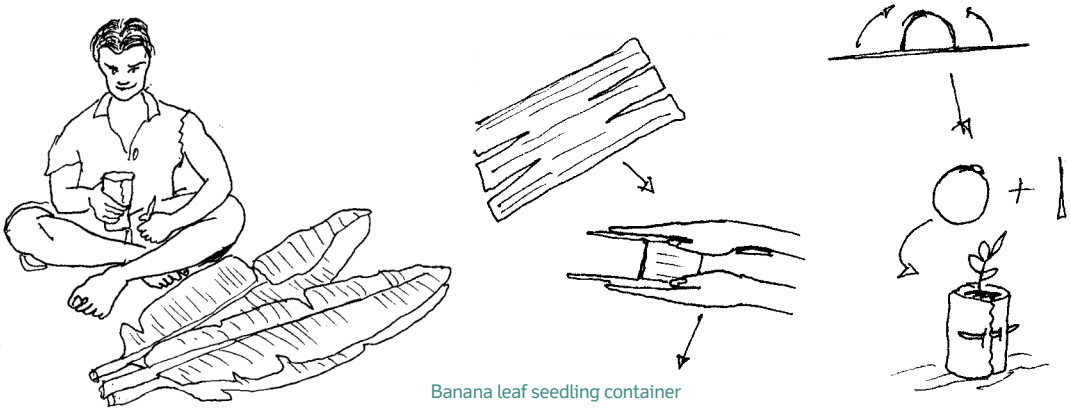
- Coconut shells
- Bamboo
- Woven palm leaves
- Banana trunks
- Banana leaves (should be one finger length wide at the base – it is better for water retention)
- Recycled strong plastic bags – two or three together is best.
- Plastic bottles, (washed) oil containers, metal tins, old buckets, old drink containers, food containers, old tyres, etc.
- Poly bags are the easiest to use for large nurseries with a lot of trees. They cost money, but they save a lot of time and work.



Old strong plastic bags make great plant containers



Banana trunk seedling container



Banana leaf seedling container

POTTING MIXES

Do not dig soil from the ground for your potting mix! Good potting mixes for nurseries and containers are very different to the soil in the ground. When starting a nursery it is a good idea to make your potting mix first.

The most important part of making a good potting mix for seedlings is to make sure that the plant roots grow easily and water drains well. It is also important to provide a small but steady supply of complete nutrients for seedlings.

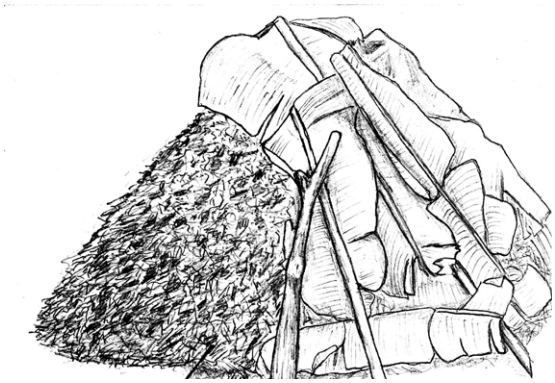
For the best results use different potting mixes for specific needs. Below we explain different potting mixes for different plants and different techniques. These specific potting mixes improve success rates and the plants grow faster and stronger too.

GENERAL POTTING MIX

- 33% compost OR crushed and aged animal manure (e.g. goat, cow, horse, elephant) Sift the compost first to remove particles 1cm or larger. If you use pig manure add less as it is stronger than other manures. Aged manure means at least three months old. A mix of manures is best, and compost is better than manures if possible.

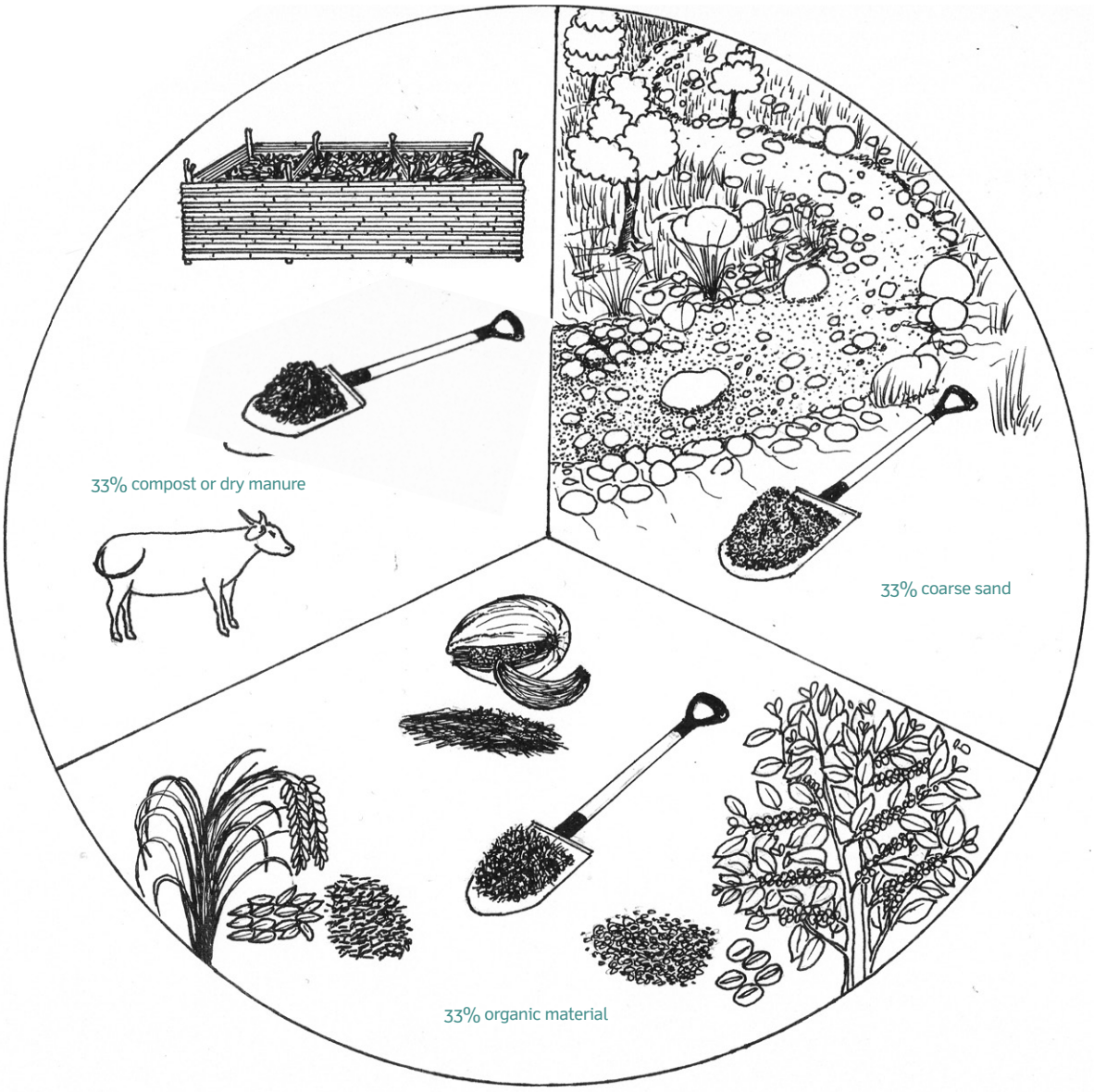
  Do not use chicken/duck/bird manure or fresh manure because it might burn the seedlings.
- 33% coarse sand (grains 2 to 4mm thick is best). Coarse sand provides good drainage and aeration for easy root growth. Fine sand is not good and will hold too much water. You can substitute some crushed charcoal for sand and it will improve the potting mix and your results.
- 33% organic material. Dried rice husks OR ground coconut husk, OR dried coffee husks OR a mix of the three. Coconut fibre can be scraped against a wire frame to grind it. Make sure that the coffee husks are well dried or even composted before using them because if they are fresh they are too acidic. They also take in nitrogen as they dry out as part of the decomposition process: if you add them fresh they will remove nitrogen from the potting mix.

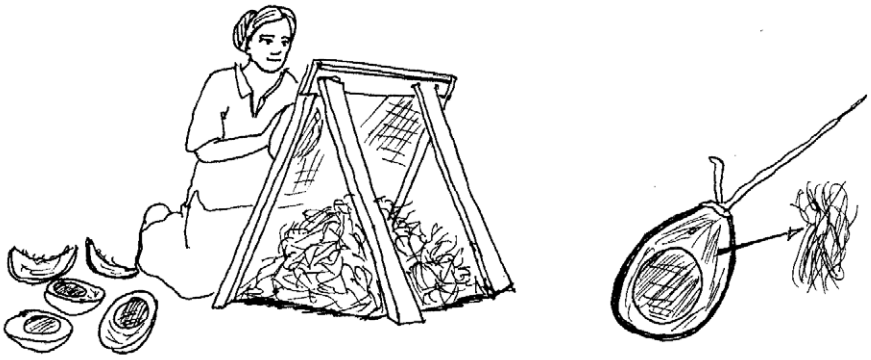
Extras: Add two handfuls of wood fire ash to 20 litres of potting mix to improve the potting mix and help balance the soil PH. Crushed charcoal is excellent material for potting mix, especially if it comes from bamboo. It can be part of the 33% coarse sand.



Dry compost

Fill containers





Ground coconut husk is great for potting mix

POTTING MIX FOR SEEDS

Plant seeds need a steady supply of nutrients for the first month of growth, and it is best that it comes from the potting mix, not from added fertiliser. If your potting mix is good then extra fertiliser is only needed for plants that have grown in a nursery for more than one month.

Use the basic potting mix for seeds, as described on the previous page. Here are some examples of other potting mixes for seeds if you have less compost available:

- 25% compost/dry manure
- 25% soil
- 25% sand
- 25% ground coconut husk fibre, dry rice husks or dried coffee husks

OR

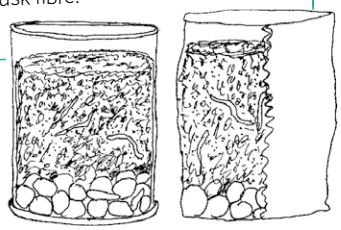
- 50% ground coconut husk fibre, sand or dry rice husks or dried coffee husks
- 25% compost/dry manure
- 25% soil

OR

- 25% compost
- 50% sand
- 25% rice/coffee/ground coconut husk fibre

SMART IDEAS:

- Soil from the ground does not make good potting mix for nurseries and must be mixed with other materials. It is only recommended if you have no other compost or dry manure available. Be careful when using soil in your potting mix as it may contain pathogens (organisms capable of producing disease) which can impact plant growth and even kill them. If possible sterilise the soil first to prevent this from happening. Put the soil in a bucket(s) and pour boiling water over it. Leave it until the water cools. This method is not 100% effective, but steam sterilisation is too difficult and expensive for most farmers. It may be possible if you are part of a nursery cooperative.
- Put 2cm of gravel at the bottom of the seedling containers before you put the potting mix in. This will improve the water drainage.
- A community nursery could buy a coconut husk shredding machine. This would not only save a lot of time but it could also make money by renting out the machine or selling shredded coconut husk fibre.



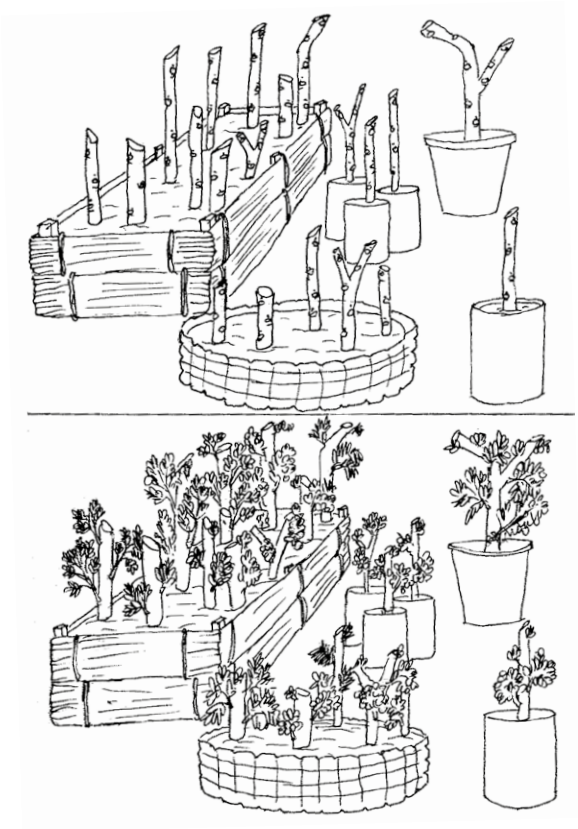
Cross-section showing 2cm gravel at the bottom

POTTING MIX FOR CUTTINGS AND PROPAGATION

Plant cuttings only need a small amount of nutrients for the first month of growth. Too many nutrients can cause problems.

Potting mix for cuttings

- 25% compost OR crushed and aged animal manure (e.g. goat, cow, horse, elephant)
- 75% sand



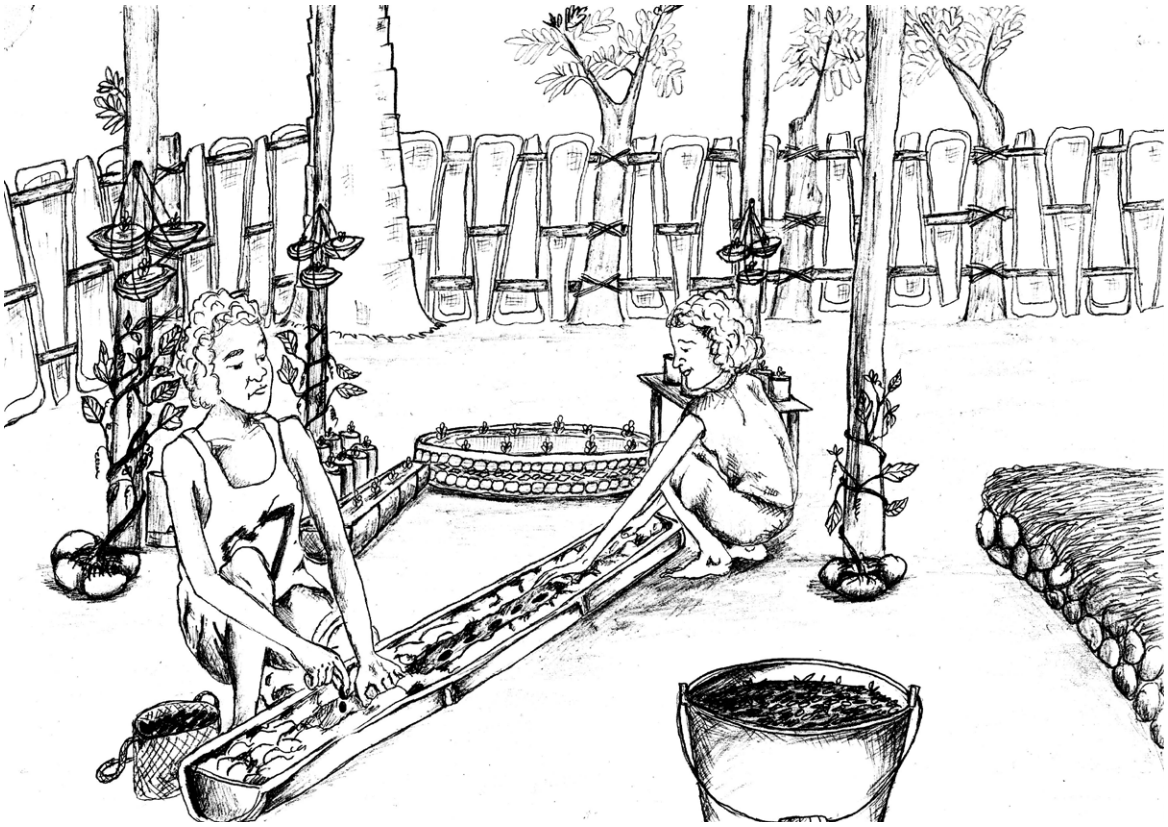
POTTING MIX FOR LONG-TERM PRODUCTIVE TREES AND PLANTS

Trees and plants that have been planted into containers or poly bags need more nutrients to grow well. It is important to add more compost or dry manure to the soil mix and use liquid compost for fertiliser. Here are some examples of potting mix for long-term trees and plants:

- 30% compost/dry manure
- 30% sand
- 40% organic matter

OR

- 25% sand
- 25% organic matter
- 25% dried manure/compost
- 25% soil

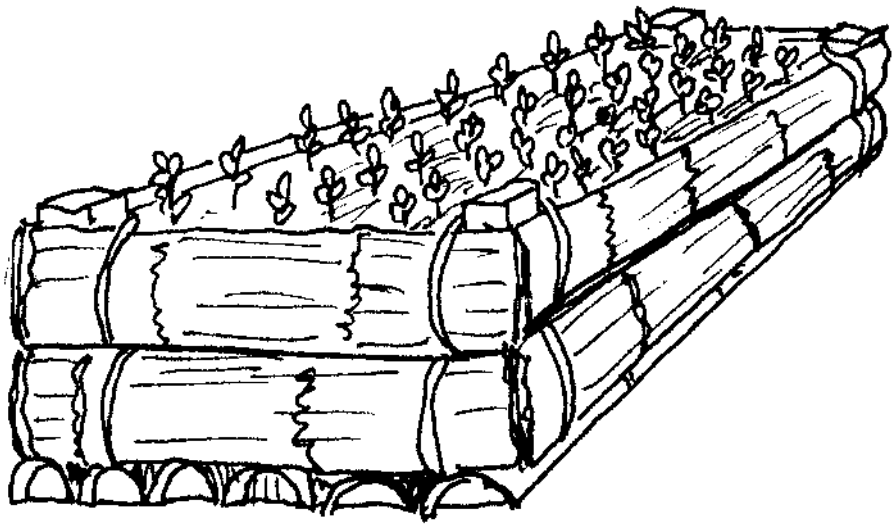


POTTING MIX FOR NATIVE TREES

Native trees do not need as many nutrients as productive trees and often like more sand in the potting mix. If you add too much manure and compost to potting mix for native trees they grow faster at first, but they will not be as strong or healthy when you plant them in the ground.

Try this mix:

- 25% compost/soil
- 50% coarse sand
- 25% rice/coffee/ground coconut husk fibre



PROBLEMS OF TOO MANY NUTRIENTS AND FUNGUS

Too many nutrients cause plants to grow too fast. This gives them weak stems and makes them vulnerable to pest and disease. When you plant them in the ground they are much more stressed and can die. Never add chemical fertilisers to potting mix. Read in the nursery maintenance section about adding fertiliser.

In the wet season, the seeds and seedlings may become affected by fungus in the potting mix.

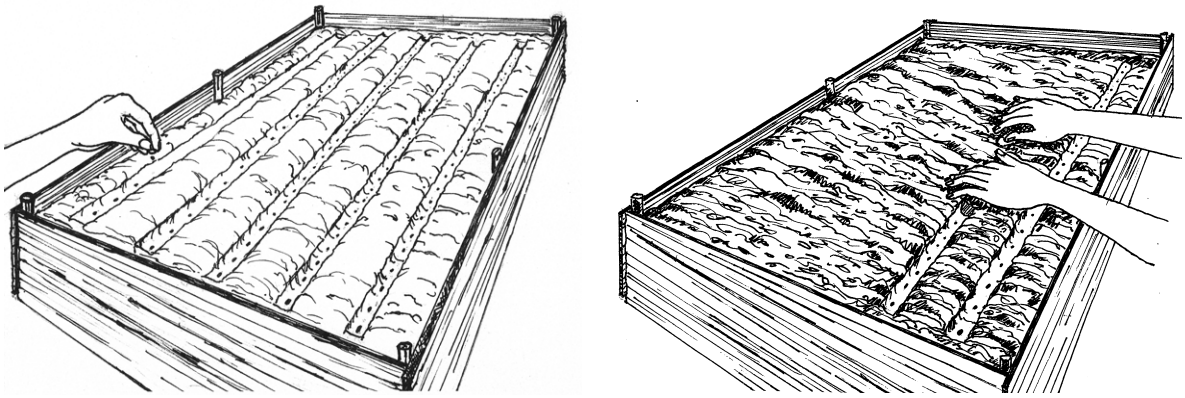
This is a common problem that stops seeds from growing and makes young seedlings rot.

If this happens to your seeds, there are four solutions you can use to stop this problem:

1. Put more coarse sand in the mix.
2. Add up to 10% crushed charcoal to the mix.
3. Check the planting depth of seeds: placing them too deep can cause fungus problems.
4. Stop giving liquid compost for at least two weeks.

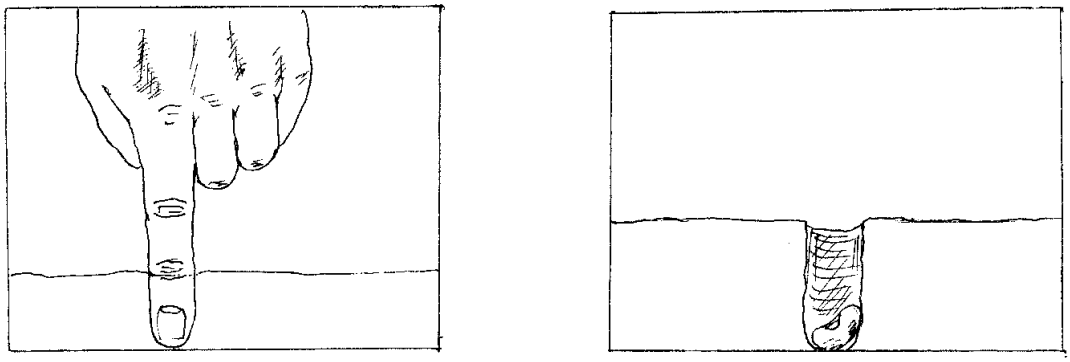
PLANTING SEEDS

- Small seeds should be planted about half a finger knuckle deep in the potting mix, and are most easily planted in furrows. Make sure the potting mix is firm, and make half a knuckle deep furrows in the potting mix. Sow the seed into the furrows and lightly cover the seeds with potting mix. Press down on the potting mix with a board making the area firm again.



Small seeds

- Large seeds should be planted about one finger knuckle deep and can be planted individually or in deeper furrows.



Large seeds

- Vegetables that grow better when the seeds are planted in a nursery are cabbages, tomatoes, green-leaf vegetables, spinach, eggplants, capsicums, onions, chilis, cucumbers, peas, okra, lettuces, and mustard.
- Vegetables that grow better if the seeds are planted straight into the garden are pumpkins, corn, beans, peanuts, radishes, sunflowers, luffas, squashes, gourds, and melons.

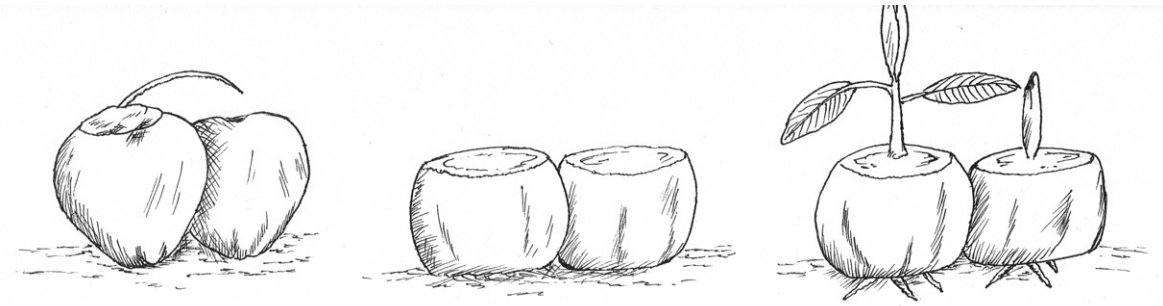
Most tree seeds need to be planted in a nursery. In some situations legume trees and papaya trees grow better if they are planted straight into the ground: e.g. living terraces, living fences, pigeon peas, sesbanias, and papayas in a mixed tree system.

Any time that seeds are directly planted, the area must be protected from animals.

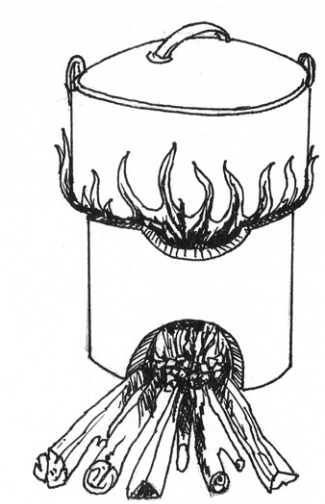
It is good to label each type of seed and plant. Write the name and date when they were planted. This is very important for large nurseries and community nurseries.

IMPROVING THE SEEDS SUCCESS RATE

- Most vegetable seeds and legume tree seeds should be soaked overnight before planting; 18 hours is best. This will increase the amount of seeds that grow and the seedlings will grow faster.
- Some hard-coated tree seeds you can soak in hot but not boiling water, and leave them overnight. This will help soften the outer skin and the seedlings will grow much sooner. If you boil 1 litre of water and leave it to cool for ten minutes, it will be ready for the seeds.
- Another method for hard-skin seeds to grow faster is to scratch the skin on cement or sandpaper. Do not scratch through the outer layer, just the surface.
- Some big seeds with very hard shells like candle nut, macadamia, and casuarina can be opened using a burning technique. In the nursery dig a shallow hole (5cm deep), and place the seeds in it. Cover the hole with sand, place some dry grass on top, and burn the grass. When the burning has finished sprinkle water onto the sand and seeds. The water causes the shells to crack. When the seeds sprout and are a few days old, remove them and replant into pots.
- Coconuts – cut off the top and bottom to help the roots and shoot to grow easily.

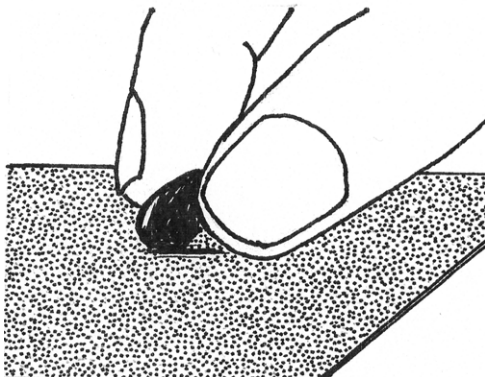


Improving success rate for coconuts

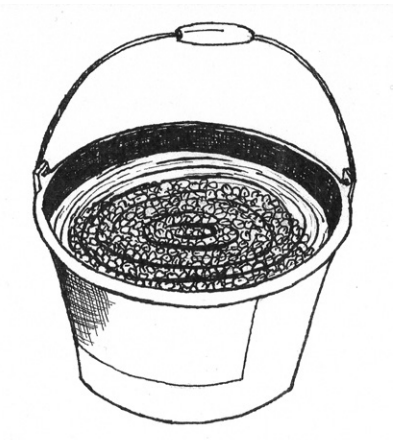


Improving success rate for hard-skin seeds **1a**: Boil water

1b: Leave 10 minutes then pour over seeds



OR **2**: Scratching the skin of hard-skin seeds



3: Leave overnight for all seeds

WHEN TO PLANT

- Vegetables usually take about three to four weeks from seeds to planting in the garden.
- Fast growing trees take two to three months.
- Slow growing trees take three to five months.

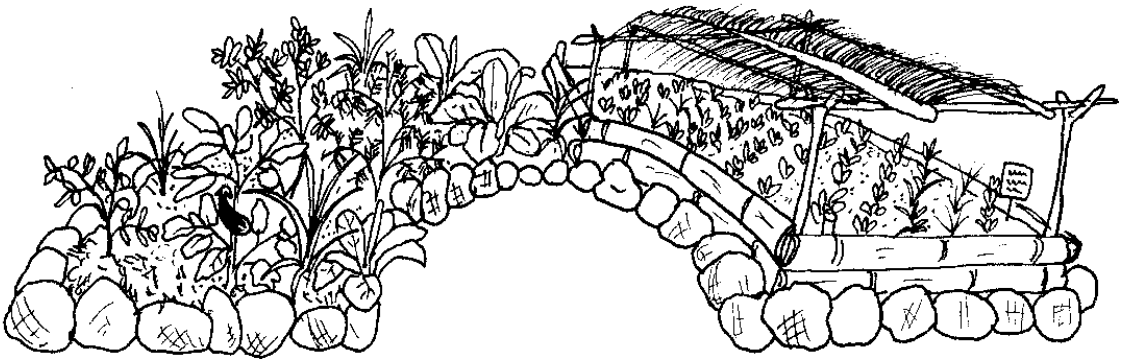
Plant the tree seeds so that the seedlings are ready to plant in the ground at the beginning of the wet season.

ROOT PROPAGATION PLANTS

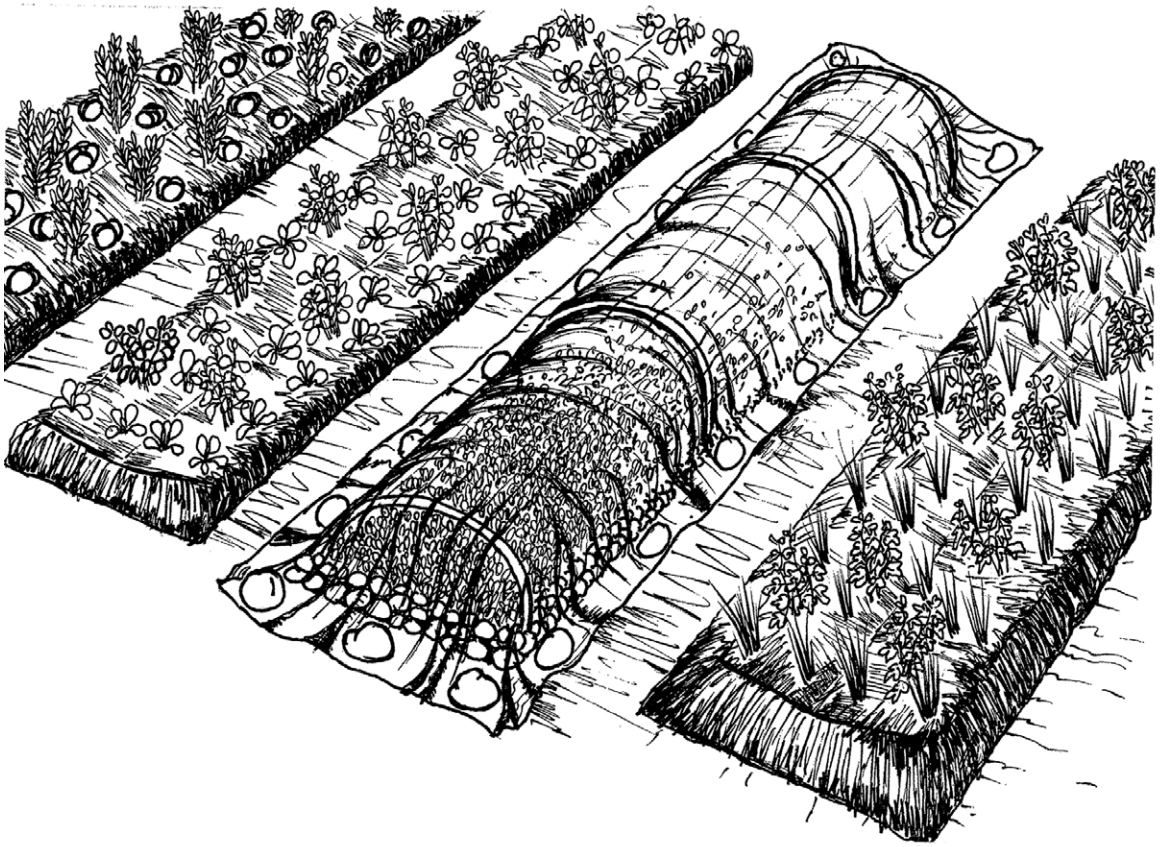
All vegetables and plants that are grown from dividing roots or stems can be planted in a nursery, but they grow better when they are planted straight into the ground and mulched well: e.g. sweet potatoes, potatoes, cassava, water spinach, watercress, taro, garlic, onion bulbs, yams, ginger, and bananas.

GARDEN PLOT NURSERIES

Sometimes it is easier to grow vegetable seedlings in the vegetable garden by converting a garden plot or two into a small nursery. As most large seed plants are best planted directly into the soil, these nurseries are for small seeds. Add some sand, shredded coconut husk/rice husks and some compost/dry, crushed and aged manure to improve the soil quality and remove all the sticks and stones. It should be raised about 15 cm above the surrounding area. Use a flat board to make the soil firm and dig half knuckle deep furrows in the soil. Sow the seeds into the furrows and lightly cover the seeds with soil. Make the soil firm by putting the board on the soil and standing on it. Finally, put a thin layer of mulch on the soil and water the seed bed.

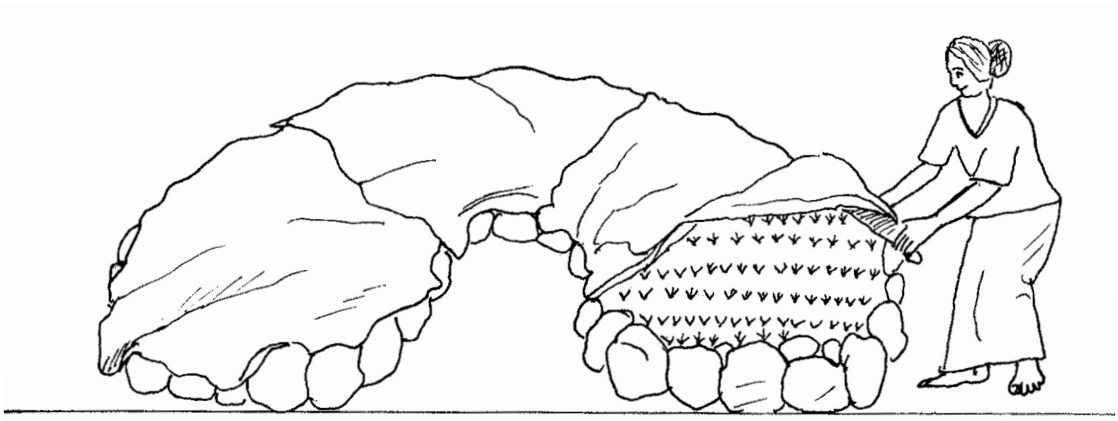


Provide shade from the midday sun with a simple structure using split palm leaves or coconut leaves.



Carrots are a special case. They grow much better if they are planted straight into the ground, but they need special attention to improve germination and growth.

1. Dig up the soil very well before planting. Add some sand (if possible) if the soil is clay.
2. Water the ground.
3. Plant the seeds very close to the surface and spread a thin layer (1/2cm)of sand or fine soil on top.
4. Press down on the soil firmly with a board.
5. Water again and cover the ground with old material or sacks for about a week to keep the ground moist.
6. Water a little each day if there is no rain.
7. Check the seedlings daily. When they first start to grow, remove the cover and keep watering every one to two days for two weeks.



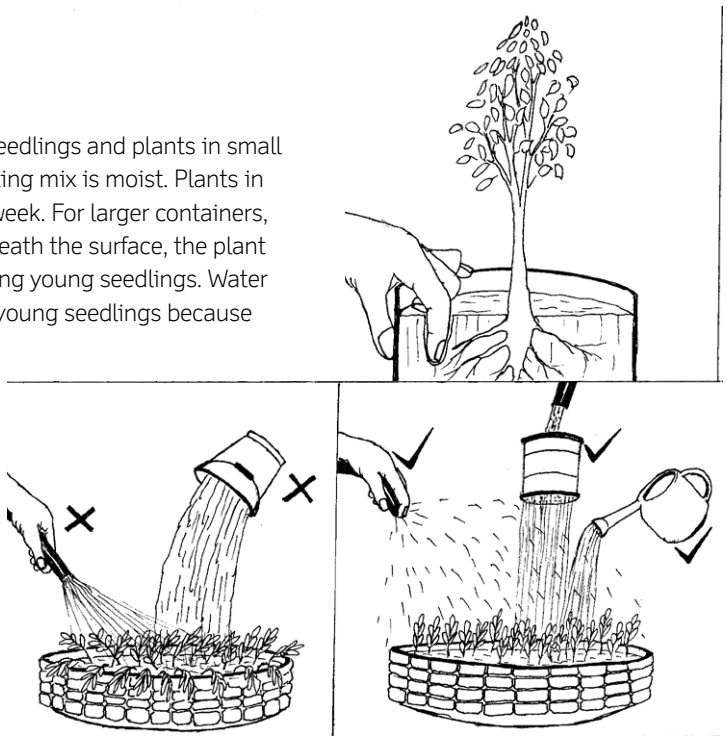
You could try fresh rice husks instead of sand/soil and cover the area with some material, but make sure you keep it moist.

NURSERY MAINTENANCE

It is important to check the nursery every day. The more attention you give to the young seedlings the better they will grow, and the more they will produce. Research shows that plants react well to being cared for and even grow better when music is played to them! This could become part of your nursery maintenance!

WATERING

Plants in a nursery need watering regularly. Seedlings and plants in small containers need water every day until the potting mix is moist. Plants in larger containers need water once or twice a week. For larger containers, if the potting mix is dry one knuckle deep beneath the surface, the plant needs water. Be very, very careful when watering young seedlings. Water them gently! Too much water at once can kill young seedlings because they are very fragile.



FERTILISING

Seedlings grow stronger and faster if they have enough food (nutrients). It is BEST if the nutrients come from the compost included in the potting mix. This will lead to stronger and healthier plants later on. They do not need a lot. Use a supplement of liquid compost if needed, especially if the seedling leaves show yellowing or slow growth. Liquid compost is good because you use it as often as is required and it has a wide variety of nutrients. Refer to the Soil chapter (**Ch 9**) for details on making liquid compost. Dilute at 75 – 100ml per litre of water, and use it once every two to three weeks. Do not use liquid compost on new seedlings until they are a month old. Fruit trees take longer to mature and will require regular liquid fertilising.

Plants in containers will suffer if you use too much manure in the potting mix or use too much liquid fertiliser. It is better to give the plants only a small amount of fertiliser in the nursery and more when they are planted into the ground. This is especially true for native trees that will be used for reforestation.

SMART IDEA:

For tree seedlings, add a handful of soil from under a mature tree to the water when you are watering seeds/seedlings of the same variety: e.g. from a mango tree for mango seedlings, pigeon pea bush for pigeon pea seedlings, mahogany tree for mahogany seedlings. This adds good microorganisms that are beneficial for that particular tree, and is especially good for legumes to make sure they have the bacteria needed for producing nitrogen. You only need one application, as early as possible after germination. Add a handful of soil to a bucket, fill it with water, stir well and apply; a small amount for each seedling is enough.

SMART IDEA:

Instead of watering the new plants, a smart idea is to have buckets of diluted liquid compost into which you can dip the containers with the newly planted seedlings. Dip until the liquid covers the potting mix surface for about ten seconds. This will remove air pockets, add fresh nutrients and good microbes, and help settle the new plants.

TRANSPLANTING

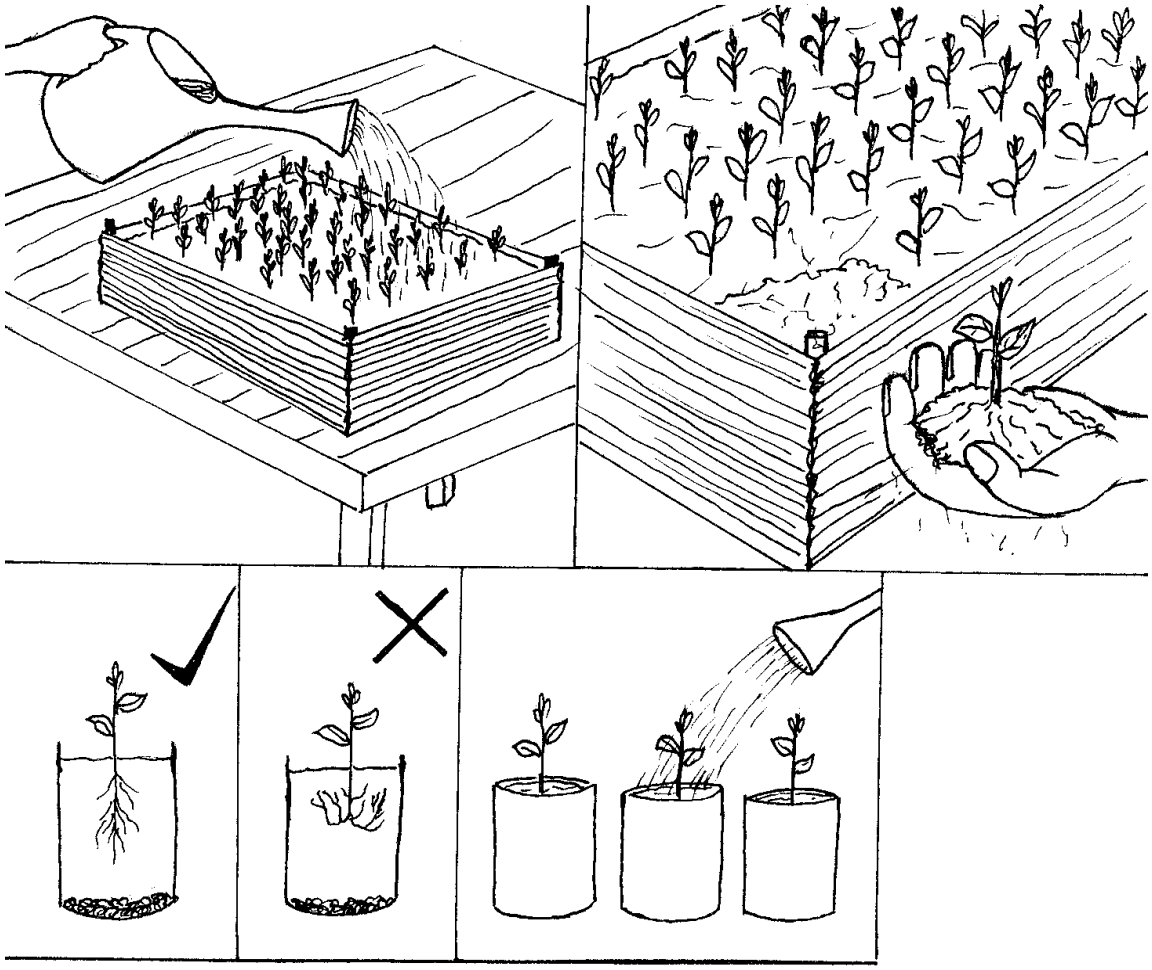
Sometimes young tree seedlings need to be transplanted into a larger container in the nursery.

Step 1: Water the seedlings well.

Step 2: Dig up the seedlings with a small shovel, digging bar or by hand. DO NOT pull up the seedlings by the stem!

Step 3: If there are many seedlings together, separate the roots very carefully.

Step 4: Immediately replant the seedlings into new containers. Fill the container to a quarter full, hold the seedling where you want it to be and very gently add the rest of the potting mix. This helps to pull the roots down into position. Firm the soil and water well.



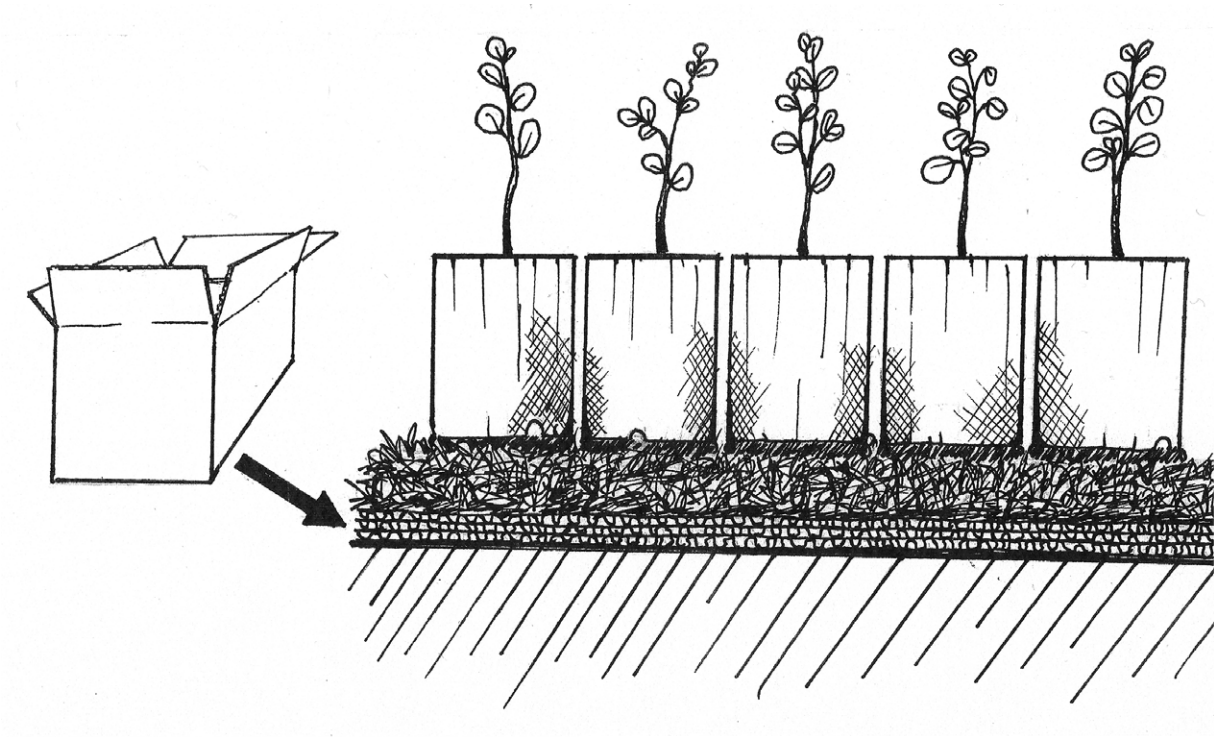
WEED CONTROL

Weed control is very important in nurseries.

Continually remove any weeds that grow in the seedling containers. They compete with the seedlings and slow their growth, which decreases productivity, especially for vegetables.

Benches and tables in the nursery will reduce weed problems because the plants are off of the ground.

If the pots are on the ground first put a layer of newspaper or cardboard then coffee husks, rice husks, sawdust or grass. Then put the pots on top. This prevents weeds growing up from the ground into the pots.



PEST AND DISEASE CONTROL

Always look out for pests and diseases in a nursery because they can spread very easily. The best solution is to prevent problems before they occur:

- Reduce plant stress as much as possible by shading from the hot sun and allowing gentle winds through the nursery.
- Use good potting mix.
- Give enough water.
- Provide enough fertiliser.
- Raise the containers and boxes off the ground.
- Place the table legs in containers with water to stop ants, snails, and slugs.

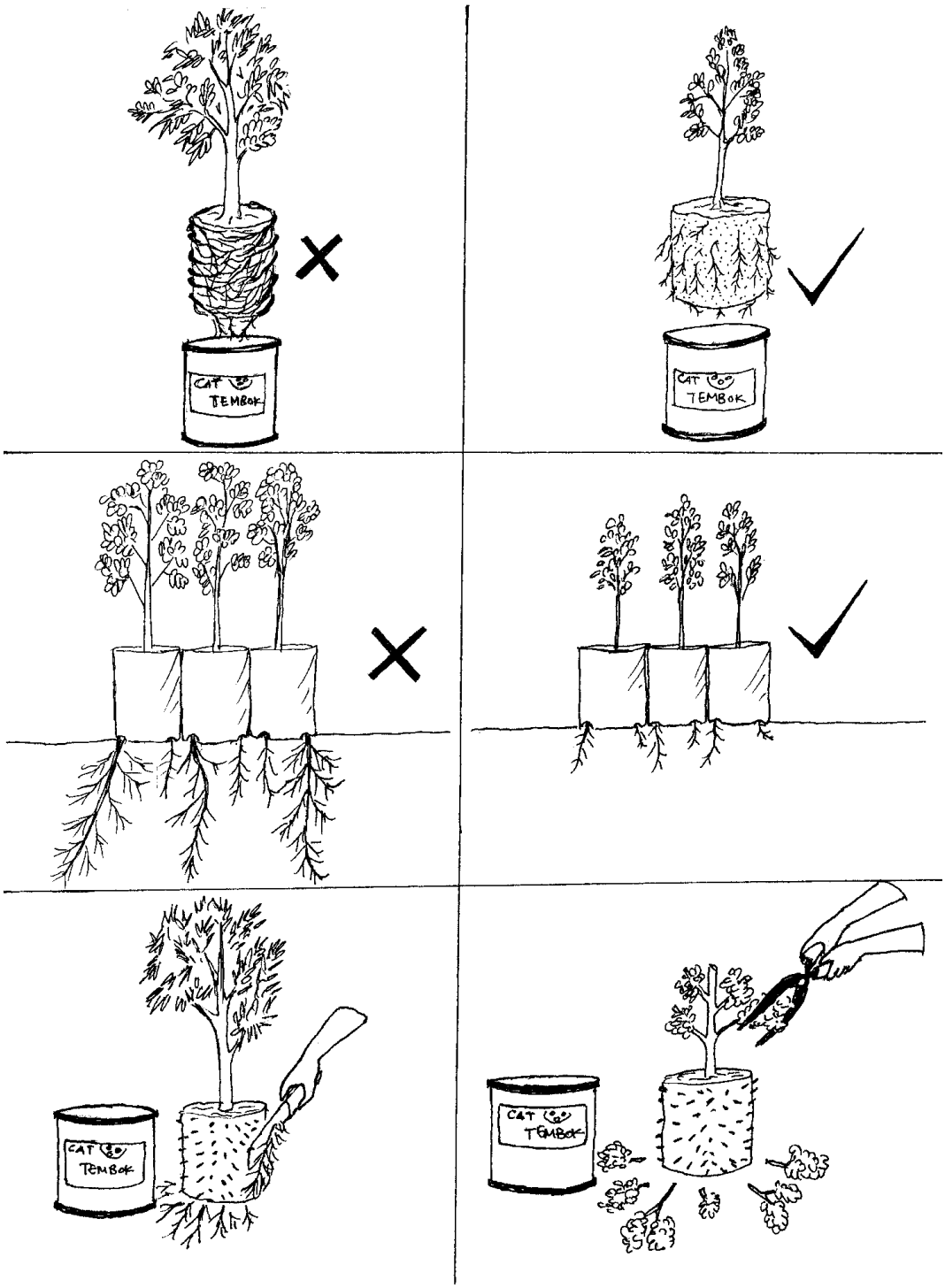
You can reduce the chances of pests or disease spreading from plant to plant by mixing the different varieties of plants together or putting them in small groups instead of large groups. If your plants are sick or attacked, you can:

- Spray with a natural pesticide. See IPM chapter (**Ch 14**) for details. Do not use chemical pesticides.
- Change the climate conditions: e.g. if a plant is suffering from fungus or mildew try giving it more sunlight and wind. This can help for some pest problems as well.
- If other solutions do not work, remove and burn diseased plants.

PREVENTING ROOT PROBLEMS

Plant roots are the MOST IMPORTANT part of a young plant. Healthy, happy roots will lead to a healthy and productive plant or tree. There will always be more roots than leaves when the plant is young.

All trees that you grow should be planted out in the ground before the tree roots grow too large for the container. If the roots grow too large they will start growing around in circles and get tangled. This is called being "root bound". This will slow down plant growth a lot and may even cause the plant to die later on.

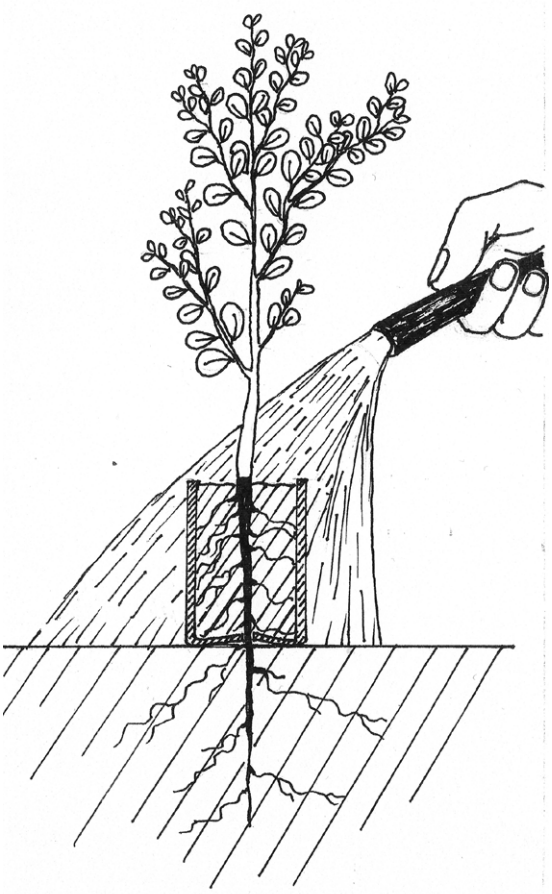


Good management for root bound plants

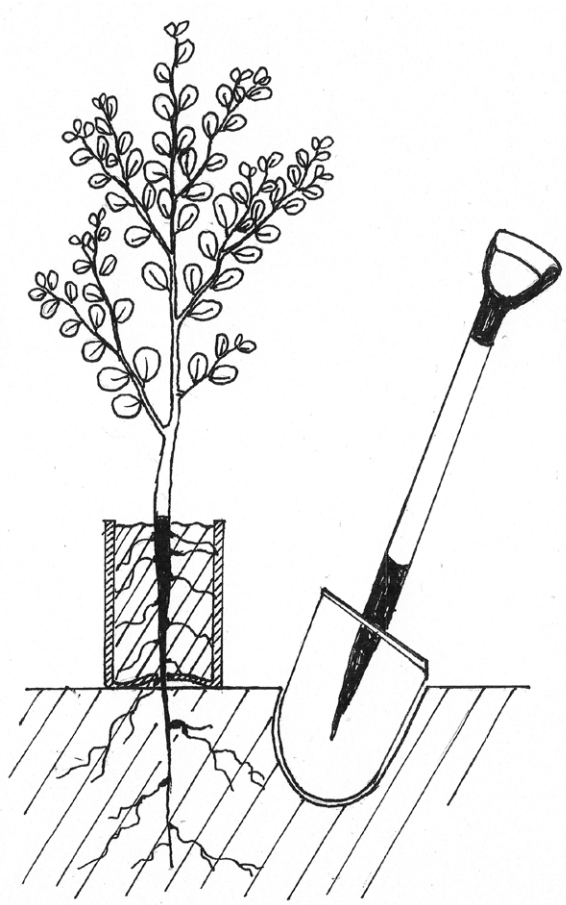
It is also important not to let plant roots grow out of the container into the ground. A small amount is not too bad. However, if a lot of roots grow into the ground and you have to break the roots before planting, the plant will be damaged and might die later on.

Grow the plants so that the roots are only just starting to fill the containers at the beginning of the wet season. This is usually two to three months for fast growing trees and three to five months for slower growing trees. It will help if you put all tree boxes and containers above the ground, on old tin, wood, bamboo, etc. Then their roots will not grow out of the container into the ground.

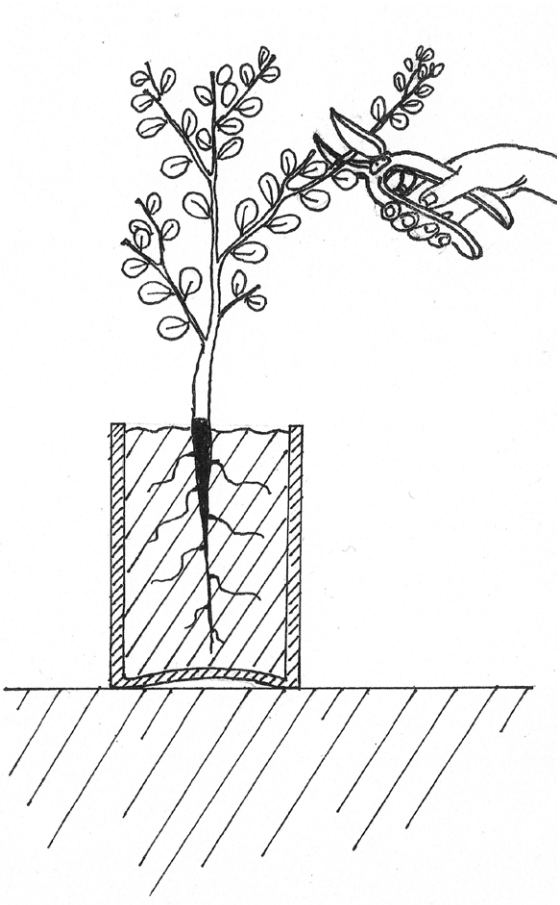
If a plant does get root bound, you need to trim off the outside layer of roots to encourage new roots to grow. If you do have to cut roots or a main root has grown into the ground and broke off, you must prune back some branches as well. Always prune more from the branches and leaves than you prune or lose from the roots.



1: Water plant and ground well



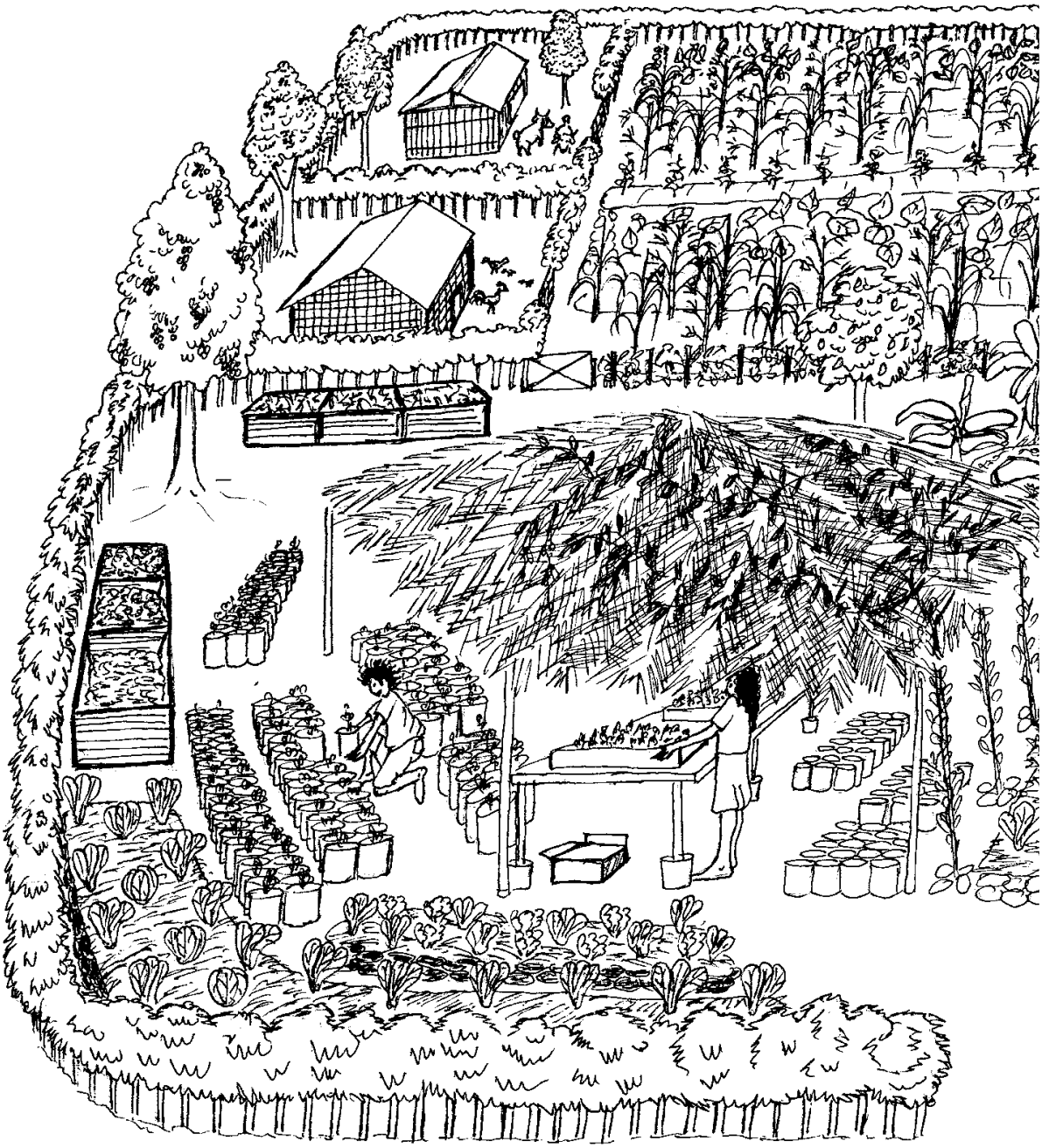
2: Carefully dig up plant retaining as many roots as possible



3: Replant in bigger pot and prune branches

HARDENING PLANTS BEFORE PLANTING

All plants that are grown in a nursery need to be "hardened" before they are planted in the ground.



Full sun hardening area

All plants that are grown in a nursery need to be "hardened" before they are planted in the ground.

This means to prepare them for where they will grow. Most plants need to be placed in the sun.

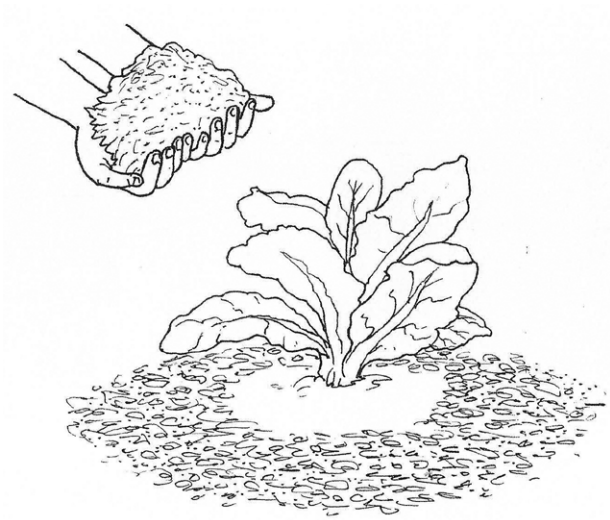
Only plants that are to be planted in the shade, like coffee and vanilla, can remain in shade.

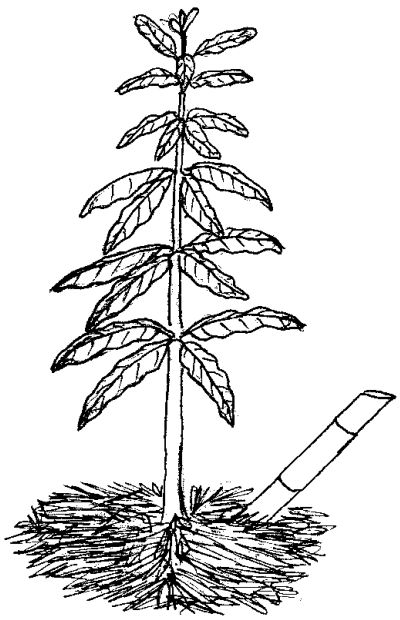
- Trees need three to four weeks to "harden" before they are planted out
- Vegetables need a week

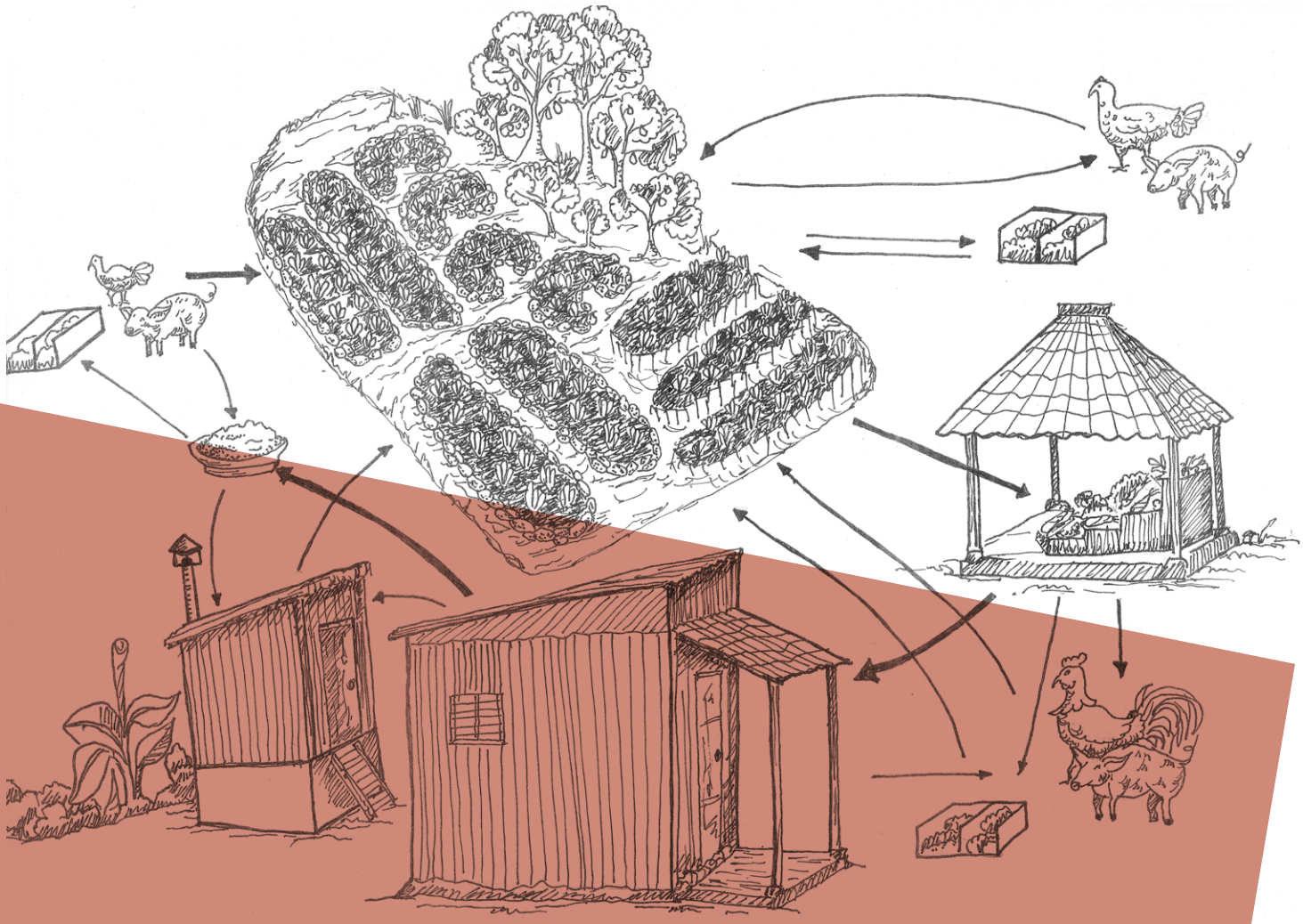
"Hardening" a plant is very important because it reduces the stress on the plant when planting it. If a plant is not hardened it will stop growing for a few weeks, many leaves will fall and the plant even might die from the stress.

Another technique for reducing plant stress is to give it midday shade for up to a week after it is planted.

The less stress plants have, the better they will grow: it is the same as people!







REFERENCES

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Websites for permaculture and sustainable communities 3

GENERAL WEBSITES 4

VOLUME 1 PERMACULTURE AND PEOPLE 5

Ch 1 Permaculture ethics and principles 5

Ch 2 Natural Patterns 5

Ch 3 Permaculture design techniques and strategies 5

Ch 4 Urban and community permaculture 5

Ch 5 Cooperatives 7

Ch 6 Trainers Guide 7

VOLUME 2 HOUSE AND GARDEN 8

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Ch 9 Soils 11

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Ch 14 Integrated Pest Management (IPM) 14

Ch 15 Trees 14

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Ch 17 Animals 15

Ch 18 Aquaculture 16

BOOKS 17

References

Websites for permaculture and sustainable communities

We searched a great many websites as we wrote this guidebook. To the website authors and information providers, thank you – you have all contributed to the content of this guidebook!

The growing number of websites providing detailed information and techniques allow better access for everyone and a more equal spread of information. However, sometimes it is hard to find and separate the good websites from those that are not so useful, especially when the internet is slow and/or expensive. Therefore, we have collated some of the best and most useful sites we found and listed them here. We have also included websites that build on the knowledge provided in the guidebook, especially for topics that are too large to explain in detail. Use these sites to research topics, design better permaculture systems and successfully implement your ideas. Bookmark them to make future access easier and share the links.

As the internet grows, it is also becoming more interactive, allowing you to collect and share information, network from local to global perspectives, participate in online workshops and training, generate business and much more.

The following list starts with general websites that provide information and access to large databases on permaculture, sustainability and regenerative practices as well as permaculture groups that you can join. The section after it links websites to the chapters in the guidebook and parts within each chapter to make finding what you need as simple as possible.

Please note: Websites update regularly, may modify their addresses or links, close occasionally and sometimes change permission for use. The following list is only up-to-date at the time of publication. We will update this list regularly and apologise if you have problems, but any changes to the websites are beyond our control.

Contact us if you have any websites to add to this list or notice any problems or changes with websites that are listed here. Thanks!

BEWARE of viruses and scams! There are many viruses that can wipe data from or, at worst, permanently damage your computer, external hard drive or flash drive (USB). Internet cafes have an especially bad reputation for sharing viruses. Only use your external hard drive or flash drive in computers that have up-to-date virus protection, and when your computer is connected to the internet be very careful what you download and which websites you visit.

Search engines

Search engines are incredibly useful, especially when you type in at least four key words to make your search accurate and specific. However, every search on the internet uses energy because of the vast amount of computer processing needed for each search to happen quickly.

There are many different types of search engines now. Some are more sustainable and ethical, such as Ecosia, which donate money from every search to environmental and reforestation projects to offset the search energy used. Another is DuckDuckGo, which does not save or sell your searches to big companies, protecting your privacy. Other search engines are more environmentally aware as they use renewable energy for their computer processing or donate money to charities. Research the search engines available and choose wisely!

General websites

http://permacultureaustralia.org.au
The website for Permaculture Australia and home of Permafund, which supports grassroots permaculture projects across the globe. Contains a lot of excellent news and information too.

www.holmgren.com.au
About the work of Permaculture co-originator David Holmgren, with a lot of useful information and links, especially the 'Permaculture' and 'Ideas and actions' tabs.

https://knowledgebase.permaculture.org.uk
A fantastic store of practical knowledge, links and resources on the Permaculture Association Britain website.

https://permies.com
Where permaculturists around the world present and discuss techniques and strategies on anything to do with permaculture.

https://permaculturenews.org
The Permaculture Research Institute website is a huge store of articles and information on permaculture as well as online forums and the permaculture global network.

http://www.appropedia.org
Amazing and extensive website - a continuously growing source of information on a huge range of topics. Almost every chapter of this guidebook can link to this website for further information. Use their portals then browse portal topics or search for what ever topic you want in the top right search box.

www.journeytoforever.org
An NGO website that covers a huge range of detailed technical information. Topics include community development, organic gardening, alternative technology, seed saving, reforestation and much more. Extensive links to other websites and a great schools project section as well.

www.villagevolunteers.org/resources/sustainable-village-library
A very useful collection of projects, research, curricula, and guides.

http://tropical.theferns.info
Amazing tropical plants database, full of information including cultivation, food uses, medicinal uses and propagation techniques.

www.foodtank.com
General food related website by a think tank pushing for food systems change, with lots of articles and links to related networks and groups.

http://www.infonet-biovision.org
A Kenya based and African focused website but very useful information for all tropical regions. Good for specific information on all organic farming and agriculture, human health, good nutrition and environmental management.

http://answers.practicalaction.org/our-resources
Available in multiple languages with videos or PDFs for download. A huge range of practical information on topics relating to permaculture

https://www.zotero.org/groups/1855053/permaculture_research/items
A permaculture research library that covers many different permaculture and permaculture-related topics.

https://www.wikipedia.org
Wikipedia: a general free reference source in multiple languages - very important and a great example of open source information. A great starting point for any research and detailed information on plant varieties.

https://www.permaculture.org.uk/about/international
Current location for the following international permaculture networks and projects:

- **CoLab - Collaborative Laboratory**: An emerging online network for scaling up permaculture locally to globally
- **PIRN - Permaculture International Research Network:** Connecting researchers, showcasing results, providing a permaculture evidence base
- **IPEN - International Permaculture Education Network:** Practical actions to make permaculture education more effective and cohesive

https://ecovillage.org/
Homepage for the Global Ecovillage Network which 'envisions a world of empowered citizens and communities, designing and implementing pathways to a regenerative future, while building bridges of hope and international solidarity.' This multi-language website links to active groups around the world, and the resources tab leads to news, blogs, a solutions library and more.

http://www.regenerationhub.co
Multi-language website for Regeneration International, connecting the global regeneration movement and providing a platform where you can access projects and groups across the world.

https://www.thebigfix.org/
Collating and sharing positive news and information about solutions to our global problems

Volume 1 Permaculture and people

Ch 1 Permaculture ethics and principles

https://permacultureprinciples.com/resources/free-downloads/
Free downloads of David Holmgren's Essence of Permaculture and colour posters in multiple languages

Ch 2 Natural Patterns

https://vimeo.com/138951606
A fundamentals of patterns lecture given by Bill Mollison. Copyright to Network Productions Inc (**www.networkearth.org**)

https://vimeo.com/139753183
A patterns application lecture given by Bill Mollison. Copyright to Network Productions Inc (**www.networkearth.org**)

https://en.wikipedia.org/wiki/Patterns_in_nature
Provides background knowledge about patterns in nature including how and why they occur.

Ch 3 Permaculture design techniques and strategies

https://www.youtube.com/watch?v=y6j103TDhMg
'What is permaculture?' short video by Rosemary Morrow in English with French subtitles. Good for the basics of permaculture, patterns and design.

http://www.rivendellvillage.org/beginners-guide-to-permaculture.pdf
A PDF download with some good information on design techniques and lots of great illustrations

http://www.suncalc.net
Very useful tool for calculating sun position and movement at any time of year at any location around the world.

Ch 4 Urban and community permaculture

https://transitionnetwork.org
The transition network is an international movement of communities coming together to reimagine and rebuild our world. The website explains the transition idea, process and goals, how to join or create transition groups and has lots of articles, stories, information and blogs.

DISASTER RISK REDUCTION AND PREVENTION

https://lists.riseup.net/www/subscribe/permaculturedrr
A global permaculture group working to support and promote permaculture for disaster risk reduction (DRR), disaster prevention and emergency preparedness. Also a Facebook group: Permaculture and disaster risk reduction.

www.idepfoundation.org
Loads of fantastic resources on disaster risk reduction can be purchased through their media page - **http://www.idepmedia.com/** or contact them at **info@idepfoundation.org**

Cookstoves, ovens and solar cookers – See Ch 8 Food, health and nutrition section

Sustainable house design and construction – See Ch 7 Houses, water and energy section

TREATING CONTAMINATED SOILS WITH FUNGI

http://www.resilience.org/stories/2014-07-07/mycoremediation-bioremediation-with-fungi-growing-mushrooms-to-clean-the-earth-a-mini-review/
A good technical explanation of the process, but hard for people without good English language skills. Contains links to other articles and papers too.

Use search words 'clean contaminated soil with bioremediation fungi' to find many videos, including - **https://www.youtube.com/watch?v=KO1WjFRL_XA** about how mushrooms are helping to clean up oil spills in the Ecuadorian Amazon.

COMMUNITY SUPPORTED AGRICULTURE (CSA)

https://communitysupportedagriculture.org.uk/what-is-csa
An explanation on community supported agriculture with further links at the bottom of the page.

https://en.wikipedia.org/wiki/Community-supported_agriculture
A detailed explanation of the American version of community supported agriculture.

FOOD SOVEREIGNTY

http://www.globaljustice.org.uk/what-food-sovereignty
Good explanation of food sovereignty and some of the groups working with communities and farmers to achieve it. The 'Find out more' section at the bottom of the page is very useful.

www.viacampesina.org
Comprehensive multi-language website of the international peasant movement for food sovereignty. With lots of information, articles, manuals and videos available, the website is easy to use and easy to find local groups and events.

http://www.foodsovereignty.org
Global initiative representing food sovereignty efforts and producing articles and guidelines enabling local groups and communities to be more effective and better equiped.

www.foodfirst.org
The website of Food First who work to end the injustices that cause hunger and help communities to take back control of their food systems through research, education and action.

SOCIOCRACY AND DEEP DEMOCRACY DECISION MAKING AND GOVERNANCE TOOLS

http://www.sociocracy.info/about-sociocracy/what-is-sociocracy
Very detailed website about what sociocracy is and how it can be applied and used.

http://sociocracy30.org
Slightly different version of sociocracy with detailed information and all open-source.

http://www.deepdemocracyinstitute.org
Website for the Deep Democracy Institute that explains about deep democracy and the methods, purpose and programmes involved.

http://deep-democracy.net
Deep democracy training and information.

LOCAL ECONOMIES AND CURRENCIES

https://transitionnetwork.org/about-the-movement/what-is-transition/reconomy
These pages from the Transition Network website provide information and links on creating strong and resilient local economies, including local currencies.

http://www.centerforneweconomics.org/content/local-currencies
Detailed information about local currencies and a large list of links to further resources and organisations.

https://www.community-exchange.org/docs/Community_Currency_Guide.pdf
Excellent PDF about community currencies - what they are, how to set one up and case studies.

http://grassrootseconomics.org/bangla
Local currency initiative in Kenya with great explanatory video.

https://www.community-exchange.org/home
Global community exchange portal where you can connect with groups around the world that operate various types of exchange systems for goods and services.

Ch 5 Cooperatives

www.ica.coop
The International Cooperative Alliance multi-language website is an extensive and detailed website. It is very useful and based on cooperative ideals. A lot of the information is based around larger organisations, not small community cooperatives, but it can be adapted.

Ch 6 Trainers Guide

Rosemary Morrow has an excellent book called 'Earth User's Guide to Teaching Permaculture'. It is very useful for anyone teaching or wanting to teach Permaculture Design Courses and is available from **http://www.bluemountainspermacultureinstitute.com.au** or other online permaculture bookshops.

http://www.bluemountainspermacultureinstitute.com.au/resources/permaculture-teaching-matters
Rosemary Morrow's free-to-download guide for a Training of Trainers course. This is very important for improving the quality and effectiveness of all permaculture training. Just reading this book is very useful! In this guide there is a **reference section (P178)** that provides many links to many other articles, websites and training information.

https://www.learning-styles-online.com/overview
This page outlines seven difference styles of learning and you can click on each style to learn more about them. Here is a good infographic: **http://edudemic.com/wp-content/uploads/2012/11/7-styles-of-learning.jpg**

https://www.permaculture.org.uk/ipen
Current website for the International Permaculture Education Network (IPEN) project. Through practical actions IPEN is looking to increase coherence and effectiveness of permaculture education across the world with a strong focus on tropical countries.

https://www.permaculture.org.uk/ipen/education-resources
A range of downloadable resources for permaculture education.

Volume 2 House and Garden

Ch 7 Houses, Water and Energy

HOUSES AND BUILDING

http://naturalhomes.org
Full of amazing pictures, lots of information and inspiration about natural building, natural energy and much more. A lot of the information is for temperate climates but many ideas can be adapted for tropical climates.

http://www.earthbagstructures.com
Very detailed multi-language website describing many different examples of earth bag building in words, photos and diagrams. There are links at the bottom of the page to other useful natural building websites and blog sites.

https://insteading.com/blog/earthbag-homes/
Great range of examples of earth bag building - photos, videos, explanations and many links to other good websites too.

www.networkearth.org
Use the "Art of Natural Building" section in this website to find a lot of information about natural building with explanations of how to use different building materials. Great information, but unfortunately not many pictures. Has information on other topics as well.

www.oasisdesign.net
Has a lot of good information about all aspects of house design and construction, compost toilets, grey water systems etc. Use the links button to find many other useful websites

http://theconstructor.org/structural-engg/bamboo-reinforced-concrete-mix-design-construction/15054
Detailed information about using bamboo instead of reinforced steel for building foundations

http://inhabitat.com/this-amazing-bangladeshi-air-cooler-is-made-from-plastic-bottles-and-uses-no-electricity
or
http://observers.france24.com/en/20160602-bangladesh-air-conditioner-plastic-bottles-technology
Build a natural air conditioner for cooling a house using simple materials including old plastic drink bottles

http://www.climatechangenews.com/2012/01/10/let-there-be-light-solar-power-bottles-bring-affordable-light-to-the-masses
Article and video on using plastic bottles to make solar sky-lights.

COMPOST TOILETS

http://www.pacificwater.org/userfiles/file/mr0249.pdf
Excellent PDF on compost toilets explaining about different types for different situations, with lots of illustrations and simple clear text.

WASTE

www.theworldcounts.com
Amazing real-time facts about resource use, waste and over-consumption.

https://wasteaid.org.uk/toolkit
Great range of PDF downloads on waste management, reusing waste and creating small businesses from reusing waste products.

https://inhabitat.com/lego-like-building-blocks-of-recycled-plastic-allow-colombians-to-build-their-own-homes
One of many examples about turning plastic waste into building products or furniture.

WATER

http://www.warkawater.org
A website about a project, technologies and products for collecting, storing and providing clean water in difficult places. Click on **http://www.warkawater.org/warka-tower/** for information specifically about the water collection technology.

http://www.fastcodesign.com/1670546/a-simple-solar-oven-makes-salt-water-drinkable
A simple solar oven design for making salt water drinkable on a family scale.

https://en.wikipedia.org/wiki/Portable_water_purification
Good general information about various forms of water purification and how they work.

https://sawyer.com/products/sawyer-mini-filter
A product that can be used for filtration of water to drink, and the website also explains about the process of micron filtration.

WATER PUMPS

http://www.climate-kic.org/case-studies/turning-on-the-tap-with-aqystas-barsha-pump
A water pump that uses water flow energy to pump water for irrigation.

https://answers.practicalaction.org/our-resources/collection/mechanical-power-1
Webpage with PDF downloads about various water pumps.

ENERGY

https://answers.practicalaction.org/our-resources/community/energy-6
A great multi-language resource of guides, projects, case studies and examples about a range of energy topics – biogas, solar, wind, hydro, biofuels, mechanical power and more.

https://energypedia.info/wiki/Main_Page
Comprehensive website that explains in detail about different forms of renewable energy and fuels. It provides case studies from many countries and information on how to build, maintain and secure an appropriate energy supply.

http://www.energyplanet.info
Alternative energy news, and information about renewable energy technologies. Use the index on the right to access a range of websites on specific topics.

http://reneweconomy.com.au
A good website for following the latest developments in renewable energy. It is Australian focused but also has a lot of articles from around the world.

https://www.youtube.com/watch?time_continue=5&v=3AZv6MjZylo
The first part of this video explains a very simple biogas system, after that a more complex system is explained, which could easily be adapted and simplified.

http://thepreppingguide.com/make-your-own-biogas/
Information on how to make a simple biogas system with photos, and a good video at the bottom of the article for a larger biogas system using simple materials. Please note - we are only referring to this page of the website, which is not a recommendation to the entire website.

BICYCLE POWERED TECHNOLOGIES

http://offgridquest.com/energy/pedal-power-how-to-build-a-bike-generato
How to build a bicycle powered generator

http://www.dacres.org/media/articles/energy/Bicycle-powered-food-station.pdf
A PDF about how to build a grain grinder and food processor using bicycle technology

https://simplyresourceful.blogspot.com.au/2017/01/how-to-build-bicycle-powered-grain-mill.html
A blog page with instructions, photos and video on how to make a pedal powered grain grinder.

CH 8 Food, Health and Nutrition

NATURAL NUTRITION

http://foodplantsolutions.org/programs-category/programs
Click on the country you want for simple but detailed and excellent information on nutritious local plants in many tropical countries in downloadable PDF format. Some country information is still in draft format because the project is steadily developing new materials for more countries.

http://aciar.gov.au/files/node/15487/factsheets_web_version_pdf_74613.pdf
PDF factsheets about nutrient dense green vegetables for the tropics with information about growing, harvesting and using the vegetables as well as the nutrient content.

FERMENTED FOODS

http://bonzaiaphrodite.com/2010/07/eat-your-beasties-the-importance-of-cultured-and-fermented-foods
Good website page for information and recipes for fermented food. All in English, and not very easy for non-native English readers, but the recipes are easy to follow and simple. Follow the links at the bottom of the page for specific recipes.

SOLAR DRYERS

http://solarcooking.wikia.com/wiki/Solar_food_drying
A multi-language website containing a lot of information, diagrams, videos and links.

https://energypedia.info/wiki/Solar_Drying
Webpage with great information on solar driers including references, further reading and project examples.

PRESERVING FOOD

http://answers.practicalaction.org/our-resources/community/food-processing-1-2
Very useful information in multiple languages on a range of food processing techniques including preserves, vinegars, dairy and drying foods, oil pressing, bottling techniques, hygiene and much more.

OIL EXTRACTION

http://answers.practicalaction.org/our-resources/collection/nut-processing-and-oil-extraction-1
A huge range of downloadable PDFs in multiple languages that explain and provide technical details for different types of oil extraction.

STOVES AND COOKERS

http://cleancookstoves.org/home/index.html
A website for an organisation promoting clean cooking options across the world. The clean cook catalogue under the technologies and fuels section shows the huge range available, with a variety of fuels including solar.

http://answers.practicalaction.org/our-resources/item/rocket-stoves-options
A small PDF showing a range of rocket stove options.

www.solarcookers.org
An excellent multi-language website about making and using solar cookers of many varieties, as well as other food technology. **http://solarcooking.wikia.com/wiki/Category:Solar_cooker_plans** takes you to plans for building many different cookers.

https://energypedia.info/wiki/Portal:Improved_Cooking
Large and in-depth page with information on stove types, fuels, impacts, monitoring, stove use, creating projects and much more.

Biochar cooking stoves – see Biochar and biochar cook stoves section in Ch 9 Soils.

Ch 9 Soils

COMPOST

http://www.compostguy.com
All about compost, liquid compost and worm farms.

BIOCHAR AND BIOCHAR COOK STOVES

http://biochar.bioenergylists.org
Full of information including downloadable pdfs and lots of small videos to watch about all aspects of biochar. It also has a discussion group and a list for many other useful biochar website links.

http://www.biochar-international.org
Comprehensive website about the international biochar movement, with lots of information under the 'Learn' and 'Resources' tabs

http://www.biochar-international.org/technology/stoves
A good explanation of the various benefits and types of biochar cooking stoves with some illustrations and many links to more information

http://www.soil-carbon-regeneration.co.uk/biochar
Good information on biochar including detailed instructions on how to make various biochar stoves. It has photos and diagrams as well.

http://servalsgroup.blogspot.co.uk/2009/05/tlud-gasifier-stoves-wood-stove-with.html
A social enterprise company website for their biochar cookstove including a short video on how to use it.

BIODYNAMICS

https://www.biodynamics.com
Official Biodynamics Association website. Good basic information and blogs, contact them about local farms, networks, courses, newsletters and more.

http://www.biodynamics.in
Indian Biodynamic website, with good basic information about biodynamics and a contact point for finding Indian biodynamic farms and courses.

BACTERIAL ACTIVATORS

http://www.compostjunkie.com
Has detailed info on bacterial activators and all things compost. Its also a shop but all the ingredients can be substituted with locally available suitable materials. You can sign up for free booklets as well.

CONTAINER WORM FARMS

http://working-worms.com/how-to-make-your-own-worm-farm
Easy to use, detailed information about making and maintaining worm farms including illustrations, short videos and pdfs to download. The techniques they use can be adapted to build worm farms with other materials as well.

http://www.countryfarm-lifestyles.com/Worm-Farming.html
Detailed information on building and maintaining worm farms but not many illustrations or photos.

http://journeytoforever.org/compost_worm.html
Really good general information which can be easily adapted for other materials.

http://www.redwormcomposting.com
A huge amount of information can be found by following the tabs on the left - for people who want to learn a lot!

Ch 10 Family Gardens

Biodynamics – see websites in Ch 9 Soils

AFRICAN KEYHOLE BEDS

https://www.sendacow.org

https://www.youtube.com/watch?v=ykCXfjzfaco
This is their short video on making an African keyhole bed.

WICKING BEDS

http://gawlerenvironmentcentre.org.au/wp-content/uploads/2016/07/Handout-2016-Wicking-Bed-Info.pdf
http://gawlerenvironmentcentre.org.au/wp-content/uploads/2016/07/Handout-2016-How-To-wicking-Foam-box.pdf
http://gawlerenvironmentcentre.org.au/wp-content/uploads/2016/07/Handout-2016-How-To-wicking-Raised-bed.pdf
Easy-to-follow PDFs about wicking beds, making them in foam boxes and making raised garden wicking beds.

HUGELKULTUR

http://www.inspirationgreen.com/hugelkultur.html
Good simple explanation of hugelkultur with great illustrations, photos, examples and links.

CH 11 Seed saving and propagation

www.seedsavers.net
The Seed Savers Network are based in Australia and have provided workshops and helped start a numerous seed saving groups in Australia and many other countries. Their website provides a lot of information, photos and blogs, as well as books and films to purchase.

GRAFTING

http://www.extension.umn.edu/garden/yard-garden/fruit/grafting-and-budding-fruit-trees
A good website that explains all the basic aspects of grafting in words and pictures. Easy to find what you want.

http://www.wikihow.com/Graft-a-Tree
Very detailed step-by-step guide for many different types of grafting, with excellent illustrations.

SEED VIABILITY TESTING

http://www.theprairiehomestead.com/2015/03/how-to-test-seeds-for-viability.html
A simple easy to follow guide for testing your seed viability rate.

Volume 3 Regenerative Agriculture

Ch 13 Sustainable Agriculture

Biodynamics – See Ch 9 Soils references

www.vetiver.org
A comprehensive website all about vetiver grass! Each section comes as an online or downloadable pdf and they all have lots of photos and very useful, simple explanations.

ALLEY CROPPING (A TYPE OF AGRO-FORESTRY)

http://www.ingafoundation.org
A great website that explains about alley cropping using the Inga tree. Some good short videos, lots of photos and information in Spanish as well.

http://rainforestsaver.org
Another great websites that explains about alley cropping using the Inga tree. Detailed information including a step-by-step guide and a great animated short video explanation

WATER CATCHMENTS

https://en.wikipedia.org/wiki/Keyline_design
A starting point for understanding good land design for water catchments using the keyline design system, with has links to further information and related topics.

SYSTEM OF RICE INTENSIFICATION (SRI)

http://sri.cals.cornell.edu
A multi-language website that contains a huge base of information on SRI for rice and other crops, including field studies, manuals, photos, videos and much more.

http://ciifad.cals.cornell.edu/sites/ciifad.cals.cornell.edu/files/shared/documents/Styger.pdf
An extensive PDF about SRI for rice and wheat that is practical, easy to read and mostly explained through photos.

https://www.oxfamamerica.org/publications/more-rice-for-people-more-water-for-the-planet
A download PDF publication about SRI showing case studies and results from Mail, India and Vietnam

MUSHROOMS

http://www.wikihow.com/Grow-Organic-Mushrooms
Simple step-by-step instructions and illustrations for growing fungi on logs and with coffee grounds.

http://journeytoforever.org/farm_library/AD40.pdf
Detailed PDF for download about the basic techniques for mushroom production

Ch 14 Integrated Pest Management (IPM)

http://www.oisat.org
Excellent online information service for non-chemical pest management in the tropics. Access the information via tabs for principles, crops, pests or control methods. It also has an extensive library and links.

http://www.infonet-biovision.org/plant_pests
A Kenya based and African focused website but has detailed pest descriptions and organic control methods that are very useful for all tropical regions.

https://www.hortzone.com/blog/2016/10/16/proven-insect-repelling-plants
Good article describing many different insect repelling plants, which also provide many other products and benefits. Other articles on this website have some good information but sometimes aren't very holistic and are occasionally linked to conventional methods or products.

https://www.softfootalliance.com/uploads/8/5/0/7/85075002/the_mobile-boma.pdf
Great PDF explaining a traditional method for protecting livestock from large wild predators

NEEM

www.neemfoundation.org
Excellent website for detailed information about neem trees, neem products and how neem works.

http://www.youthinfarming.org/2011/10/produce-neem-oil-at-home-and-earn-extra.html
Good description about extracting neem oil for household use

Ch 15 Trees

ALLEY CROPPING (A TYPE OF AGRO-FORESTRY)

http://www.ingafoundation.org
A great website that explains about alley cropping using the Inga tree. Some good short videos, lots of photos and information in Spanish as well.

http://rainforestsaver.org
Another great websites that explains about alley cropping using the Inga tree. Detailed information including step-by-step guide and a great animated short video explanation.

GRAFTING

http://www.extension.umn.edu/garden/yard-garden/fruit/grafting-and-budding-fruit-trees
A good website that explains all the basic aspects of grafting in words and pictures. Easy to find what you want.

http://www.wikihow.com/Graft-a-Tree
Very detailed step-by-step guide for many different types of grafting with excellent illustrations.

MORINGA

http://www.treesforlife.org/our-work/our-initiatives/moringa
An excellent website explaining all about Moringa's many uses and benefits. The site has a lot of other useful information too.

www.moringanews.org
A very good general website for moringa information in French and English. Also excellent for networking and the links to other groups and websites.

VETIVER GRASS

www.vetiver.org
A comprehensive website all about vetiver grass! Each section comes as an online or downloadable pdf and they all have lots of photos and very useful, simple explanations.

Ch 16 Bamboo

www.inbar.int
The International Network for Bamboo and Rattan (INBAR) website has a lot of information. It explains how bamboo can help in achieving many sustainable development goals (SDGs), offers links to a range of projects and through their resource tab offers a wide range of information about growing, harvesting and using bamboo through books, downloadable PDFs and articles.

http://www.bamboocentral.org/index1.htm
Instructions for treating bamboo with boron can be downloaded from the Environmental Bamboo Foundation - click on the treatment manual tab to access the PDF

http://www.completebamboo.com
Aimed at a USA audience, but contains a lot of good basic information on growing and maintaining bamboo for all countries.

http://www.guaduabamboo.com
A large amount of information and articles under the bamboo tab as well as free PDF downloads on lots of topics including bamboo building and bamboo furniture. (**https://www.guaduabamboo.com/bamboo-pdfs**)

http://humanitarianlibrary.org/sites/default/files/2014/02/INBAR_technical_report_no20.pdf
A large and comprehensive PDF on bamboo and using bamboo for construction

http://theconstructor.org/structural-engg/bamboo-reinforced-concrete-mix-design-construction/15054
Information for using bamboo instead of reinforced steel for building foundations. This website has other good articles on bamboo as well.

Bamboo The Gift of the Gods 2003 Oscar Hidalgo – Lopez ISBN 958-33-4298-X
This is an important book if you want to build with bamboo, especially for large buildings and for creating a livelihood from bamboo building. South American architects and engineers have been developing this technology for many years.

Ch 17 Animals

ANIMAL FEED

http://www.tropicalforages.info
A detailed website with a huge database of forage plants for animals. Use the selection tool to insert your details then access appropriate forage plants, or use the forages fact sheets to find out about any plant.

http://www.feedipedia.org
Multi-language website that provide valuable information on all types of animal feed, especially forage plants. Use the feed category tabs on the left side

CHICKEN HEALTH

http://www.worldpoultry.net/Breeders/General/2009/7/Herbal-trees-used-as-antibiotics-for-broilers-WP006936W/
An article on using plants as natural antibiotics and the results for the different plants

http://www.countryfarm-lifestyles.com/aloe-vera-for-chickens.html#.WAYlvdw7SVs
An article on using aloe vera for general chicken health and treating some sicknesses.

GOAT MANAGEMENT

http://publications.cta.int/media/publications/downloads/371_PDF.pdf
A comprehensive PDF on managing goats in the tropics. Good basic information although some of medical treatments rely too much on curative chemical treatments rather than preventative and/or natural treatments.

www.fiascofarm.com
This website contains a lot of information about goat farming, milking goats and making products from goat milk. The methods described are all natural and mostly simple. Some products described are not available here, but it still provides many useful techniques and a lot of good information.

COWS AND BUFFALOS

http://pdf.usaid.gov/pdf_docs/PNADQ897.pdf
A PDF on making silage for high quality livestock feed

https://www.softfootalliance.com/uploads/8/5/0/7/85075002/the_mobile-boma.pdf
Great PDF explaining a traditional method for protecting livestock from large wild predators

BEEKEEPING

http://answers.practicalaction.org/our-resources/collection/beekeeping-6
A range of PDFs on beekeeping in multiple languages

http://www.beesfordevelopment.org/resource-centre
The Bees for Development resource centre is divided into different sections to make finding what you need much easier, with an extensive library, teaching resources, movies, journals and more.

http://www.buzzaboutbees.net/support-files/how_to_build_a_tbh.pdf
A PDF to download on making a top bar bee hive. It has lots of photos, and is easy to follow.

http://www.planbee.org.uk/uploads/Bees_for_Development_Beekeeping_with_top-bar_hives_March_2006.pdf
Good basic management information for top bar hives in a small PDF

http://publications.cta.int/media/publications/downloads/1290_PDF.pdf
A PDF about bee products - the range of products and how to collect, make, market and sell them.

Ch 18 Aquaculture

www.enaca.org
Network of Aquaculture Centres in Asia-Pacific website. The information - articles, audio and video - is more for larger scale fish ponds and some information is based on high-external inputs or chemical treatments but it also has a lot of information that is relevant and useful.

http://www.aquaculturewithoutfrontiers.org
A range of information and presentations along with education resources in the form of blogs, articles, videos and slideshows as well as many links to other organisations and networks.

https://steemit.com/permaculture/@reville/aquaculture
From West Timor, in English language but with an Indonesian perspective. Lots of good basic information and photos, with integration techniques for other food production systems too.

Books

Books and other educational materials are vital for ongoing development. Websites are great but books can be used anywhere and provide practical references for successful projects and for reducing mistakes. Good books become treasures, to be shared and valued well beyond their worth.

We encourage local groups, organisations and cooperatives to develop a library of education resources for themselves and for the wider community to use as well. This includes:

- Books large and small
- Reference guides
- Comic style educational readers
- Children's books
- Posters and information sheets
- Flip-charts

Part of community resilience is to have education tools to develop, overcome problems and be self-sustaining.

BOOKS REFERENCED FOR THIS GUIDEBOOK

We are deeply thankful for all the information referenced and learned during the researching for this guidebook. Thank you, the writers and illustrators, for all your efforts in providing these books and reference materials. You have all contributed greatly to expanding the knowledge and resource base for tropical permaculture worldwide.

Earth User's Guide to Permaculture
Rosemary Morrow
Kangaroo Press, 1993

Earth User's Guide to Permaculture – Teachers Notes
Rosemary Morrow
Kangaroo Press, 1997

Bamboo Rediscovered
Victor Cusack
Earth Garden Books, 1997

The Seed Savers Handbook
Michel and Jude Fanton
The Seed Saver's Network, 1993

Permaculture, A Designers Manual
Bill Mollison
Tagari Publications, 1988

Introduction to Permaculture
Bill Mollison
Tagari Publications, 1991

Permaculture – Principles and pathways beyond sustainability
David Holmgren
Holmgren Design Services, 2002

Liklik Buk
Edited by Amanda Twohig
Published by Liklik Buk Information Centre,
Lae, Papua New Guinea, 1986

Sapa, The natural way of growing food in the Solomon Islands
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GLOSSARY

A

Aerate	To provide air or enable air to circulate – e.g. aerate the soil.
Agroecology	The study of ecological processes applied to agricultural production systems; the application of ecology to agriculture, as in the conservation of soil and water resources, minimising pollution, and the use of natural fertilisers and pesticides. An ecological approach to agriculture is one that views agricultural areas as ecosystems and is concerned with the ecological impact of agricultural practices.
Alignment	Organisation in a straight line, or a line/s made as such – e.g. contour lines.
Animal tractor	A small to medium sized cage with an open bottom or a fenced area usually for chickens, pigs or ducks but can be for other commonly raised animals too. The animals turn the soil, removing weeds and seeds, and fertilise it with manure. After a period of time – e.g. when the animals have cleaned or turned the ground – the tractor or fenced area is moved to a new position. This method is used after harvest and before planting the next crop.
Annual	A plant that completes its life cycle in one year.
Aquaculture	Aquaculture or aquafarming is any type of water, pond or wetland environment which grows or farms aquatic animals (e.g. fish, eels, crayfish, prawns, etc.) and plants.

B

Biochar (activated charcoal)	Biochar is a stable form of charcoal produced by heating natural organic materials in a high temperature (300 °C to 700 °C), low oxygen process known as pyrolysis. The charcoal is then made active with beneficial micro-organisms, fungi and nutrients.
Biomass	Organic matter – especially plant matter – that can be converted compost, mulch, animal fodder, fuel and soil improver.
Bulb	A bud, usually underground and circular, from which leaves, stems and flowers grow at the top, and roots from the bottom.

C

Canopy	The covering or highest layer of a forest or of an area of plants and trees provided by the tree tops, similar to the roof of a house.
Citrus	A general name for a group of trees of the same family that produce sharp tasting, often large fruit – e.g. orange, lemon, lime, mandarin, grapefruit, pomelo.
Compost	Natural high-quality fertiliser and soil improver that is made from decomposing manure, plant materials and other natural ingredients. "To compost" is to turn plant materials, manure and other natural ingredients into fertiliser.

Compost bay	A structure built and used to make and contain compost.
Condensation	The process of changing from a gas or vapour to a liquid or solid form – e.g. the water droplets that appear on cold surfaces as a result of hot air or steam cooling.
Contour line	A line connecting points of equal height, at the same level from end to end, across a slope.
Cooperative	A farm or enterprise that is communally owned and managed for the economic benefit of its members.
Cross pollination	The transfer of pollen from the male part of the flower of one plant to the female part of the flower of another plant.
Cutting	A piece of a branch from a plant that when planted grows into a new plant.

D

Deficient	Not enough; of a quantity not able to fulfill a need or requirement – e.g. nutrient deficient soil means the soil does not have enough nutrients or not all the nutrients that a plant needs.
Design	To conceive, invent, plan, devise, formulate; Permaculture design applies permaculture ethics, principles and methods to create an outcome that reflects permaculture in action no matter the location, need situation or size. The sequence of activities to complete a design is called a design process.
Diversity	Many different and mixed varieties of animals and/or plants in one area. – e.g. a healthy natural forest has a diversity of plants, animals and birds.

E

Element	One of the fundamental components making up the whole. The elements of something are the different parts it contains.
Energy	The capacity of an organism or physical system to do work. Physical systems can be people, animals, machines, etc. Energy can be created, stored and used.
Evaporation	To change from a liquid or solid shape into a vapour or gas – e.g. water when it boils or water when it dries on the road after rain.

F

Feature (on map)	An important or unique part of the land that is mapped – e.g. house, river, fence.
Fermentation	A chemical process caused by yeasts, bacteria and moulds where organic food is converted into simpler compounds, and chemical energy is produced. It is used for preserving, and making food and drinks – e.g. tempeh, yoghurt.
Fingerling	A young fish usually under a year old, about the size of an adult finger.

Fry (in aquaculture)	Young, baby fish.
Function	The intended use or purpose of a person or thing – e.g. some functions of bamboo are to stop erosion, make a living fence, reduce wind, provide poles, provide food, etc.
G	
Garden bed	An area for growing small plants. Permaculture garden beds suit the land and climate, and are designed for protecting and building soil. They are usually raised, with paths on the outside and sometimes have borders.
Germination	The process of a seed coming to life and growing.
H	
Hedge	A thick row of bushes or small trees.
Holistic	Looking at the whole of something or someone and not just its parts. Permaculture uses this approach to observe and include all separate parts into a single integrated design.
I	
Input	Something that is a resource needed for a system to function properly. In a permaculture system an input is carefully chosen; preferably it is local, sustainable, renewable and waste or output from a different system.
Integrate	Bringing together two or more individual parts or systems so they become connected and inter-related, creating a new whole system.
Integrated Pest Management (IPM)	Combines different natural techniques for pest management to reduce the chances of pest problems, the size of the pest population if problems occur and natural control techniques if necessary.
L	
Larva	An insect after it has hatched from an egg and before it changes into its adult form. More than one larva is larvae.
Leach	To lose soluble elements from a substance by a liquid passing through it – e.g. when soil loses nutrients as a result of wet season rain.
Living fence	A fence built by growing living plants close together in a row. If legume trees are planted they which can be pruned regularly to produce animal food, compost material, mulch and nitrogen in the soil.

M

Microclimate	The summation of environmental conditions at a particular site as affected by local factors rather than regional ones.
Micronutrient	A mineral or vitamin required in very small amounts by plants and animals for health and growth.
Mineral	A naturally occurring solid inorganic substance with a characteristic chemical composition and structure.
Mulch	Organic material spread on the ground and covering the soil, usually around plants, to inhibit weed growth, prevent excessive evaporation or erosion, enrich the soil and moderate soil temperatures, etc. (Mulch can be inorganic, such as plastic, but it is not recommended or sustainable.)

N

Nematode	The general name for a class of very small worms which live in most environments including the soil. Most types of soil nematodes are beneficial but some types are parasitic and cause damage to plant roots by eating them.
Nursery	A protected area where plants are grown from seeds, seedlings or by propagation in order to transplant into other areas or to sell when they have reached the appropriate healthy size.
Nutrient	A substance that provides the food necessary for life and growth.

O

Organic matter (OM)	Material in or on top of the soil which is of plant or animal origin.
Output	Materials, products or yields that are created. In permaculture all outputs, even waste, are used and reused as inputs in other parts of a house, community or production system.

P

Pathogen	Any virus, bacterium or other micro-organism that can produce disease.
Perennial	A plant that continues its growth for three or more years.
Pest predator	A bird, animal, insect or spider that eats the pests which damage crops.
Photosynthesis	The chemical process by which a plant uses sunlight and chlorophyll to make sugars from water and carbon dioxide absorbed from the air.
Pioneer	A plant that is usually the first to start growing in a new area of land, which has possibly been damaged by fire or has no other vegetation – e.g. pioneer plant.

Pollination	When a powder produced by the male part of a flower is carried by insects or the wind and causes the female part of the same type of flower to produce seeds.
Prevailing wind	The usual direction the wind comes from.
Propagation	To take a section of a plant from which to grow more plants.
Prune	To cut off some parts of a tree or bush so that it grows better, removes dead or diseased branches or improves the shape.

R

Regenerate	To re-create, renew, reconstitute, or restore, especially in a better form or condition. In permaculture this can refer to trees, soil, rivers, an ecosystem and even a community. Regeneration promotes health, diversity and resilience.
Resilient	Capable of recovering easily and quickly from misfortune or illness and less prone to suffering during times of stress or hardship – e.g. Improved water catchment and storage will increase plant survival rates during drought conditions.

S

Scale (on map)	The ratio between the size of something real and that of a representation of it.
Seed saving	The act of preserving, using and increasing a seed supply from quality plant sources, by careful growing, selecting, cleaning, drying and storing the seeds each season.
Soil biota	The mainly microscopic plant and animal life in the soil.
Soil improver	A material that enhances the quality of soil, increasing biological and healthy fungal activity and/or the amount of humus or organic matter.
Succession	The gradual and orderly process of change in an ecosystem brought about by the progressive replacement of one community by another over time until a stable climax is established.
Sustainable	Something that lasts and can go on indefinitely, based on available resources. It is midway between degenerative and regenerative.
Swale	A swale is a trench dug in a line along the contour of a piece of land with a mound of soil, rocks or other materials made in a line directly below it. It is built to collect, spread and store water in the ground, and also to catch soil and organic matter. Sometimes on difficult land it is only possible to make the mound.
System	The manner in which parts of something fit or function together; a network or set of methods for doing something – e.g. a permaculture design brings separate strategies and techniques together into one system.

T

Tree (or living) terrace	A system of raised flat banks of soil, usually on a hillside, for planting crops where the bank is formed and stabilised by a row of closely planted trees or plants, carefully chosen to be productive, good at protecting the soil from erosion , non-competitive and easily managed.

V

Value-added	When a product or material is changed, improved or processed in order to create a new product or material and increase its price or worth – e.g. making jam or marmalade from fruit; making furniture from bamboo poles; making compost from manure, leaves and kitchen waste.
Ventilation	When fresh air is allowed to enter an enclosed space.

W

Wholefood	Food that is not packaged or changed from its original form. It can be fresh, dried or naturally preserved.

Y

Yield	The results of human work and/or a natural process – e.g. In a permaculture system there are many results or yields by using all of the different functions of each element.

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